Vol. 7 APRIL, 1940 No. 4

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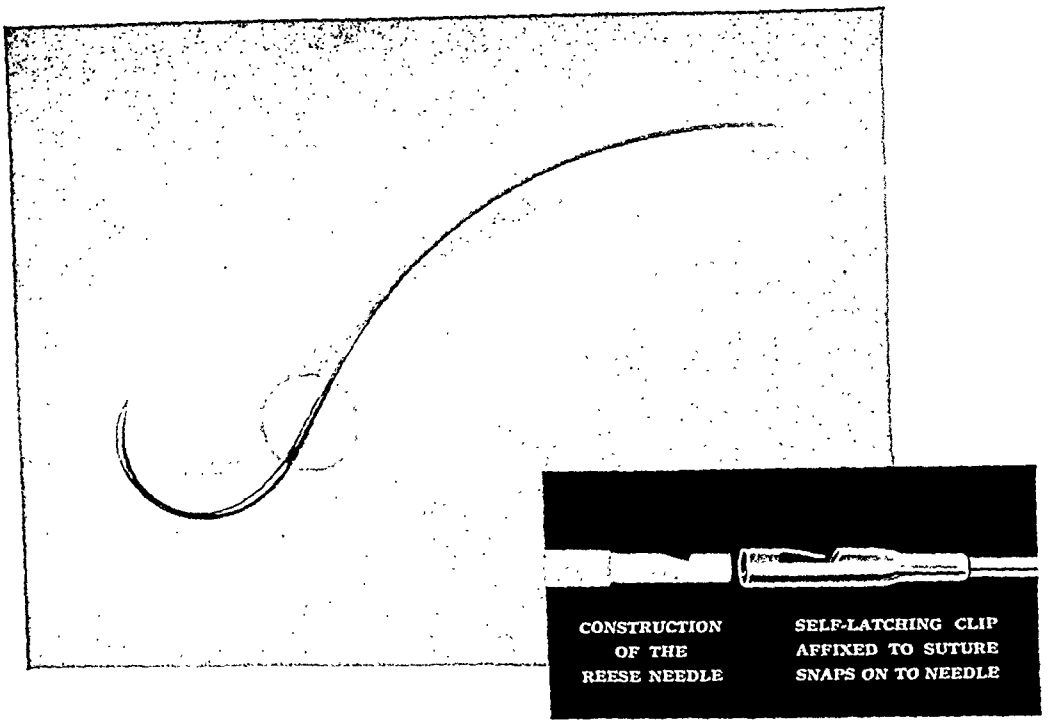
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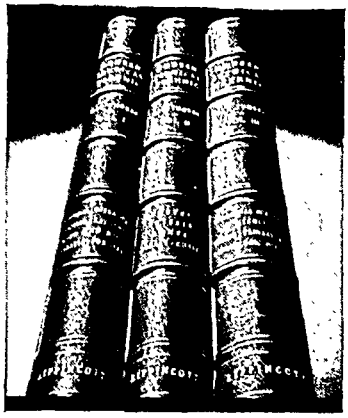
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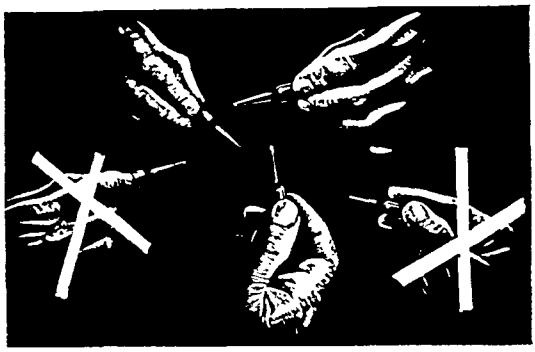
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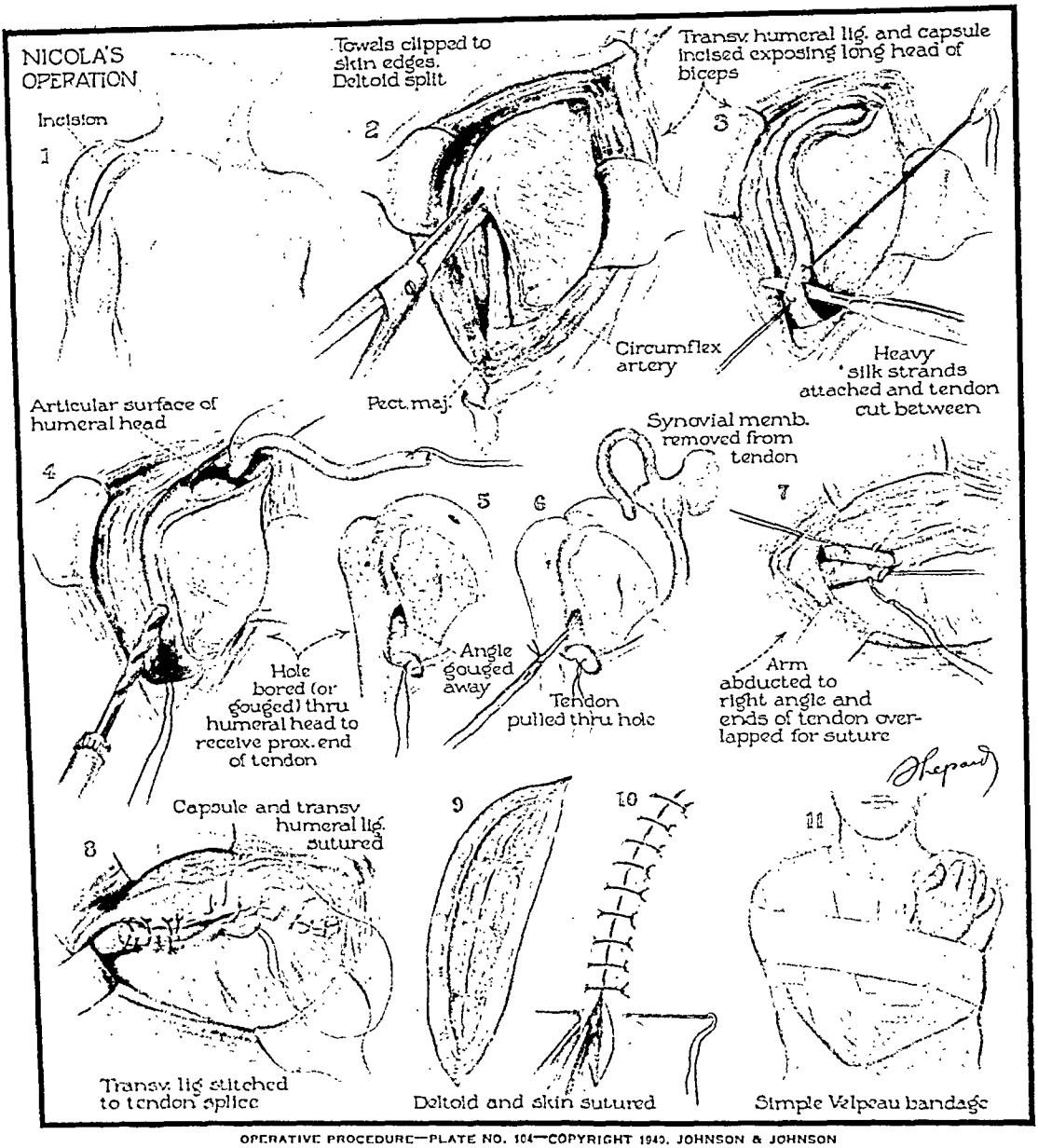
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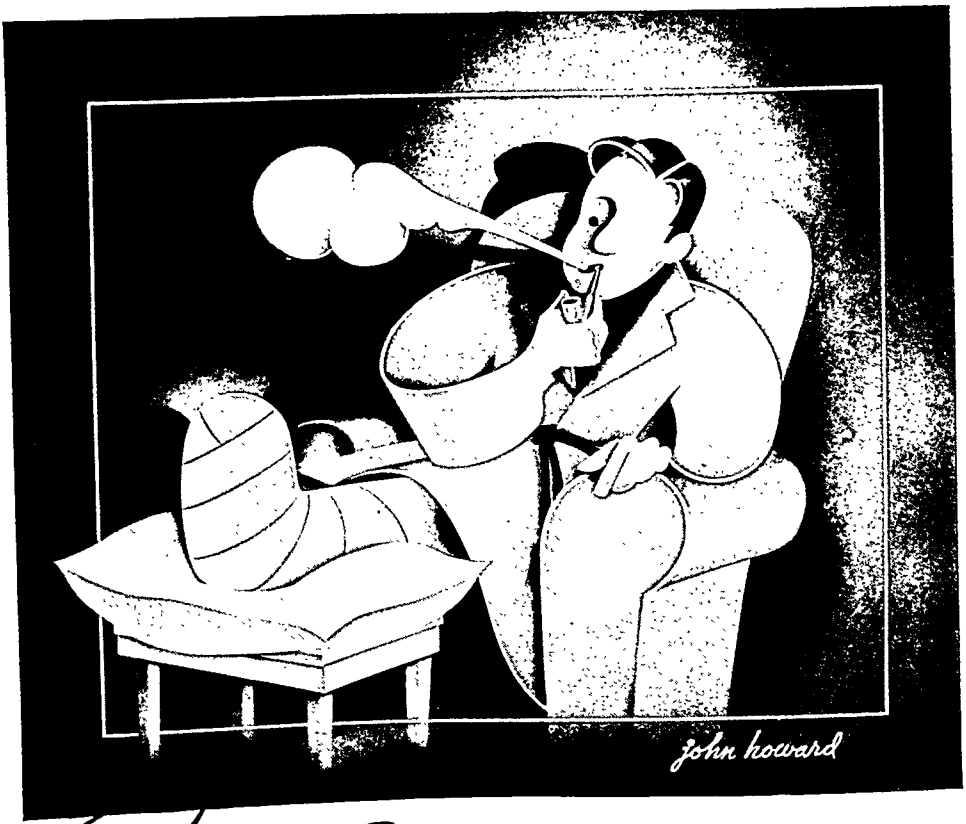


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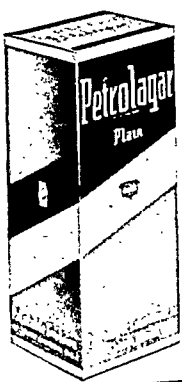
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Original Communications

THE RELATIVE VALUE OF CATGUT, SILK, LINEN, AND COTTON AS SUTURE MATERIALS

WILLIAM H. MEADE, M.D., JACKSON, MICH., AND ALTON OCHSNER, M.D., NEW ORLEANS, LA.

(From the Department of Surgery, School of Medicine, Tulane University, New Orleans, La.)

A LARGE number of investigations have been reported concerning the relative value of silk and catgut as suture materials and with few exceptions these demonstrate the superiority of the former over the latter. Because there had been no comprehensive comparative appraisal of a large number of suture materials, the present study was undertaken in order to evaluate the efficacy of catgut, silk, linen, and cotton.

Undoubtedly, today the average physician fears nonabsorbable suture because "foreign bodies" have been emphasized by pathologists and older surgeons as detrimental and this has deterred him from using nonabsorbable materials. This fear has been justified by the poor results which have been obtained but which were due to the incorrect use of the nonabsorbable suture. Unquestionably the experience of Lister,[1] whose opinion was highly regarded, greatly influenced the surgical world in rejecting nonabsorbable sutures. It was unfortunate that Lister's earliest experience with silk led him to conclude that it predisposed to infection. This belief was based upon finding, in one of his early cases, a localized collection of cloudy fluid surrounding a silk ligature ten months after ligation of a vessel for aneurysm. It remained for Kocher[2, 3] and Halsted[4] in the 1880's to demonstrate the superiority of silk over catgut. If the tenets of Halsted laid down a half century ago had been adhered to, little difficulty would have been experienced with nonabsorbable sutures. Whereas practically all of the men trained by Halsted use silk routinely in clean wounds, it remained for Whipple,[5] who had previously used only catgut, to popularize the use of silk.

Received for publication, September 18, 1939.

The numerous methods of treating and of sterilizing catgut, its variability of absorption, and the frequent charges by surgeons that catgut was responsible for infections, led Bulloch and co-workers[6] to make a thorough investigation of the preparation and sterilization of this suture material. They found that there were only two chemicals which produced sterilization of catgut; namely, hydrogen peroxide and iodine. They also found the heat sterilization process of Krönig to be excellent. Krönig's[7] method consisted of drying the catgut at 70° C. for two hours, then placing it in cumol, a hydrocarbon (boiling point 153° C.), and heating it for one hour at from 155 to 165° C. One of the most extensive investigations is that of Minervini,[8] who showed that dry heat is of questionable value as bacterial spores proved resistant and were not destroyed at less than 140° C. for three hours, and that prolonged heating at this temperature greatly reduced the tensile strength and pliability of the suture material. Obviously, pliability is essential as the tensile strength greatly decreases when a knot is tied in stiff material. Considerable credit is due Meleney and his associates[9, 10] in pointing out the possibility of wounds becoming infected from supposedly sterile catgut sutures. Meleney's interest was aroused by the occurrence of gas gangrene in five patients whose wounds should have been clean. Clock[11, 12] in a recent publication showed that of the American manufactured catgut several brands were not sterile. In 1930, 1931, 1932, and 1934, seven brands were sterile and five brands were not. In 1933, eight brands were sterile and four were not. Shambaugh,[13] in analyzing 2,360 inguinal herniorrhaphies, showed the incidence of suppurative wounds to be twice as great following the use of catgut as that following silk. In contrast to the difficulty in sterilizing catgut, sterilization of nonabsorbable suture materials can be readily accomplished.

It has been the opinion of most surgeons that the persistence of a suture after wound healing is detrimental and that in the presence of infection it alone is responsible for continuation of the infection. Because of this, catgut, which is absorbable, has been the most popular suture material. The absorbability of catgut is influenced by a number of factors as emphasized by Howes and Harvey.[14] Hemorrhage, tissue necrosis, infection, and that unknown factor, a man's personal constitutional reaction to protein, all increase the rapidity of absorption. Frequently, it has been observed by us and by many others that as early as the seventh day postoperatively no evidence of twenty-day chromic catgut in the wound can be demonstrated. Whereas increased absorbability of catgut has been explained on the basis of allergic manifestations, especially by Kraissl, Keston, and Cimiotte,[15] carefully controlled investigations by Pickrell[16] tend to disprove this.

Wound healing in the presence of catgut is definitely retarded, as has been shown by Kocher,[3] Halsted,[4] Whipple,[5] Shambaugh,[13] Howes

and Harvey,[14] and by us. The effect of catgut on the healing of wounds has been well described by Howes,[17] who showed that with plain catgut there is swelling of the strand with a zone of polynuclear leucocytes at the periphery and in the interstices. This process becomes progressively more marked up to the fourth day when mononuclear leucocytes appear. Fibroblasts then grow out and penetrate into the interstices of the suture. In the meantime, the cross section of the strand decreases and the suture is completely absorbed in from four to seven days, depending upon the size of the suture. Chromic catgut swells less, but fibroblastic proliferation begins twenty-four to forty-eight hours later. Here again absorption depends upon the size of the suture but is usually complete in from nineteen to twenty-three days. According to Howes,[17] the coaptation of the wound is entirely dependent upon the suture for a period of four days, at which time fibroblasts begin to proliferate and assist in holding the wound. Fibrosis does not reach its maximium for from twelve to fourteen days.

The chemicals used in the preparation of catgut, chromic acid salts, iodine, copper, formalin, and tannates are all deterrents to dry wound healing. These chemicals, in addition to the animal protein, produce an inflammatory reaction characterized by increased exudation which Gage[18] has termed a wet type of healing; whereas, silk, linen, and cotton produce little inflammatory reaction, thus resulting in a dry type of healing which is associated with early fibroblastic proliferation. For many years we have demonstrated to our house officers the comparative reactions of the skin to catgut and to nonabsorbable sutures by closing one-half of the wound with catgut and the other half with a nonabsorbable suture. The inflammatory reaction about each catgut suture site, consisting of redness and a seropurulent exudate, is a distinct contrast to the lack of reaction surrounding the nonabsorbable suture. It is an established fact that wound healing is retarded in the presence of infection. As previously demonstrated by Shambaugh[13] and Whipple[5] and corroborated by us, infection is much more likely to occur in the presence of catgut than when nonabsorbable sutures are used. We have repeatedly observed grossly contaminated wounds closed by interrupted nonabsorbable sutures heal per primum.

Huhne[19] has pointed out that when catgut swells it shortens, and when shortened it may break. It may untie the knot or it may break at the knot. Taylor[20, 21] demonstrated experimentally that the knot, the suture immediately adjacent to the knot, and the sites of kinks were the weakest points in the tied suture. We have corroborated these observations and those of Howes,[17] who found that a wound closed with catgut is weakest between the fourth and the eighth days due to a considerable decrease in the tensile strength of the catgut and insufficient lapse of time for fibroblastic strengthening of the wound. It is only after the eighth day that the wound becomes as

strong as the surrounding tissue. According to experiences of those (Sokalov,[22] Hesse,[23] Radlinski,[24] and Traczak[25]) who have seen and analyzed a large number of them, wound disruptions usually occur between the fifth and the twelfth days and most frequently between the seventh and ninth. Ries[26] and Fallis[27] have reported disruption as early as the second day and even then were unable to demonstrate catgut in the wound.

SILK

Silk should be classed as a nonabsorbable suture, although it is mainly protein.[28] It is pliable, easily sterilized, and, when not serum-proofed or waxed, contains no chemical other than an iron dye. Silk consists essentially of a center or core of fibroin, with a covering of serecin or silk albumin and a little waxy material. Fibroin, which is analogous to horn, hair, and similar dermal products, constitutes from 75 to 82 per cent of the entire mass. Silk is spun as a fine fiber 800 to 1,200 m. long. It is insoluble in water, alcohol, and ether, but dissolves freely in concentrated alkaline solutions, mineral acids, strong acetic acid, and ammoniacal solution of copper oxide. Silk is highly hygroscopic and, when heated to 120° C., will lose from 10 to 15 per cent of its weight in moisture. Microscopically, the silk strand is round and straight. Silk used in spinning thread is devoid of serecin or its gummy portion, due to its being boiled off in a solution of soap, following which the silk is washed until all of the alkali is removed. At this stage, the silk, which is to be white, is bleached in sulfurous acid fumes and then washed in distilled, cold water until the acid is removed. As considerable weight is lost in the boiling-off or scouring process, the addition of tin salts, usually $SnCl_4$, is sometimes made. The stannic chloride acts as a mordant so that the silk can take a black dye. Another method used in dying silk black consists of the use of nitrate of iron, fustic, hematine, and soap. Finally, the silk is washed until the soap is thoroughly removed.

Whereas silk is mentioned in some of the earliest medical writings, by Celsus, Galen, and later Trotula (A.D. 1050),[29, 30] it was not until 1888 that silk came into more general use because Kocher[31] had so many infections with catgut. From May to July, 1887, there occurred twenty-nine serious infections in thirty-one operative wounds on Kocher's wards. These he attributed to catgut and forthwith turned to silk. About the same time W. S. Halsted[4] in this country began to use silk in all clean wounds. Halsted's technique varied somewhat from that used in Kocher's clinic. These variations consisted principally in the use of fine silk in preference to coarse silk and the use of interrupted rather than continuous sutures. Halsted,[4] in 1913, emphasized that good results were being obtained in wounds closed with silk in the German clinics even though rubber gloves were not used. The tenets

of Halsted[4] are as true today as when first enunciated by him in 1893. He advised: "(1) The use of interrupted sutures only, (2) the use of silk not coarser than C, (3) to never bridge over a dead space as a chord subtends an arc, (4) to use transfixion suture in ligation as finer material could be used this way, (5) to use a greater number of fine stitches rather than a few coarse ones, and (6) to avoid the combined use of silk and catgut." As Homans has said: "In surgery, however, as in every other Art, fundamental matters are perennially being discovered, discredited, forgotten, rediscovered, and reaffirmed." Thus it is with Halsted's simple observations on the use of silk suture material. Practically all Halsted-trained men use silk and are staunch advocates of the employment of this material. More recently Whipple,[5] Shambaugh,[13] Babcock,[32] and others have advocated the use of nonabsorbable sutures. All, with the exception of Babcock, advocate the use of silk. Howes and Harvey[14] in a study of tissue reaction and wound tensile strength demonstrated microscopically that silk produced less inflammatory reaction in the tissue than catgut. The wound healed earlier and the tensile strength of the wound increased more rapidly as the fibroblastic reaction was greater and earlier than that associated with catgut. The silk soon became encapsulated in a fibrous sheath. As Shambaugh[13] states, catgut may act as a nidus of infection, and we believe that the poor results obtained from the combined use of silk and catgut are due to a nidus of infection and increased tissue reaction produced by the catgut. Whipple[5] showed that, by the use of silk in a period of three years, serious wound infections were reduced from 1.9 to 0.7 per cent and trivial infections from 8.9 to 1.5 per cent in supposedly clean wounds. Shambaugh and Dunphy[33] in experimental work on animals showed that silk wounds better tolerated slight bacterial contamination because silk was less irritating to the tissue than catgut. However, as we shall point out again, when a continuous silk suture is used in the presence of infection, a sinus frequently results.

Silk is easy to handle because, with the exception of cotton, it is the most pliable of all suture materials. One who has been trained in the use of catgut, however, as Halsted noted, will find some difficulty for a few months in becoming accustomed to this material. There is a tendency for the novice to break it, but, when this occurs, the suture or ligature is being tied too tightly and tissue strangulation would be bound to occur.

The bacterial content of unsterilized silk has apparently received little attention, although Konrich[34] and Goris[35] described with considerable detail its sterilization. This phase will be mentioned and discussed later.

Whereas untied chromic catgut has greater tensile strength than silk, the latter is still stronger than the tissue in which it is placed

and, as compared to catgut, remains so throughout the period of healing. However, as will be pointed out in the experimental work, there is greater decrease in the tensile strength of silk than is commonly thought. Silk, though smooth as catgut, has a greater tendency to cut tissue, but this may be due to excessive constriction of tissue. In addition to producing an occasional persistent sinus in the presence of infection, silk may produce a still more infrequent complication, which, although not described in the English literature, has appeared in the Continental literature. This complication is a low grade inflammatory tumor described first by Schloffer[36] in 1908. The tumor may occur from months to years after the implantation of the silk and is cured by the removal of the silk from the center of the tumor. Whipple[37] suggests that the tumor is the result of the use of too heavy silk. As these tumors have been removed as late as seven years following the implantation of the silk, it demonstrates conclusively that for practical purposes silk is nonabsorbable. We have observed two cases which were due to the incorrect use of silk before we learned to use it properly. These will be described later.

LINEN

Linen is derived from flax. Whereas flax is grown in France, Russia, Ireland, and other Middle European countries, Coutrai flax of Belgium is best, due to its strength and fineness. Belgium flax contains 52 per cent cellulose, 4 per cent extractive matter, 8.5 per cent water, 2.4 per cent fat and wax, 2.7 per cent intercellular substance, and 0.7 per cent ash. The fibers range in length from 20 to 140 cm., with an average breadth of 0.016 mm. The resinous and gummy material is largely removed by benzine prior to bleaching and the greater the bleach the less the resinous material. Fibers which are to be used for thread receive the greatest bleach.

Antyllus (A.D. 200),[29] who first attempted to cure an aneurysm with a ligature, used linen and sometimes catgut. In the thirteenth century Berlapoglia Leonardo recommended linen as a suture material. Since the time of these early writers, linen has been used as a suture material with more or less success. About 1865, Pagenstecher, a German ophthalmologist, prepared linen by treating it with a celluloid solution. This made a much more pliable suture, giving considerable less friction and less serum absorption. This suture has been used many thousands of times as a purse-string suture in appendectomies, and during the World War was used extensively by the German army surgeons[38] because of the scarcity of catgut. Apparently it has been a very satisfactory suture.

COTTON

Cotton, one of the most important vegetable fibers, is readily available as suture material in the form of ordinary thread. It is inexpen-

sive, pliable, fine, and, as will be shown, is easily sterilized. Cotton, a cellulose material, consists of unicellular hairs which occur attached to the seed of various species of plants of the genus Gossypium, belonging to the Malvaceae. Each fiber is formed by the outgrowth of a single epidermal cell of the testa or outer coat of the vessel. Microscopic examination of the mature cotton shows that the hair is twisted and flattened. This characteristic is of considerable technical importance, the natural twist facilitating the operation of spinning the fibers into thread or yarn. It also distinguishes it from silk and linen which have no natural twist and consequently have more of a tendency to fray out. Cotton thread is made from the long fiber Egyptian or Sea Island cotton. When spun, it is usually made up of six cords which do not become unraveled as easily as twisted silk or linen. In addition to the plain cotton there is a mercerized thread. The latter, as will be shown, is somewhat stronger, size for size, than the plain thread, although it contains but three cords. The process for its production was devised by Mercer in 1813 and consists essentially of putting cotton thread in a warm 25 per cent solution of potassium hydroxide for an hour, which produces a quick shrink and at the same time a glossy sheen. Following the immersion in the alkali, the cotton is either washed in running water until neutral or the alkali is neutralized by acid. When finished, the pH of the mercerized thread varies between 6.8 and 7.2.

In the year 500 B.C. Susruta[28] recommended the use of sutures in wounds of the abdomen and of joints. For suture material he used cotton, strips of leather, plaited horsehair, and animal tendons. This is the only mention of cotton as a suture found in ancient literature. Recently, in 1936, Ginkorski[39] published an article on the use of cotton as a suture material. He advised using Nos. 30 and 40 spool cotton which has been cold sterilized in a mixture of 8 per cent formalin and 5 per cent tannin solution. The sterilizing solution has been previously injected into animals subcutaneously and intramuscularly and apparently caused a painless swelling which rapidly disappeared. Besides getting good results in 100 animals, Ginkorski operated upon twenty-three human beings, using cotton throughout, with healing by first intention.

Although cotton has been used as a ligature material by Gage,[18] of Tulane University, and by Guerry, of Columbia, S. C., it has not been used for the major portion of their surgery. However, the experimental and clinical uses of this material were encouraged by seeing Gage use it frequently as a ligature.

EXPERIMENTAL INVESTIGATION

In order to determine the relative efficacy of catgut, silk, linen, and cotton as suture materials the following experiments were performed:

I. Tensile strength

The tensile strengths of the various sizes and types of cotton, catgut, silk and linen were determined:

1. On straight and knotted unsterilized, ordinary spool cotton, silk, and linen
2. On cotton, silk, and linen sterilized by boiling for varying lengths of time; sterilized by autoclaving in steam alone and in oil
3. After cotton, catgut, silk, and linen were allowed to remain in animal tissue (rabbit) for varying lengths of time

II. Tissue reaction and wound healing

The gross and microscopic reactions of tissue (rabbit) to catgut, cotton, silk, and linen were determined and compared.

III. Bacteriology.

The bacteriology of cotton, silk, and linen was studied.

1. Prior to sterilization
2. Following the destruction of the ordinary pyogens
3. Following boiling
4. Following autoclaving

Tensile Strength.—To determine the tensile strength (break strength) of sutures, a simple, frictionless method was used. The apparatus consisted of a ring stand and tubular crossbar. Approximately 60 inches of the material to be tested were wound around the crossbar. The free end of the suture was then attached to a weight holder, being wound around the cylindrical hook at the upper end. Weights, 100 gm., 50 gm., and 25 gm., increments were added every fifteen seconds until the suture broke. The length of the suture tested in each instance was 4 inches. When the suture broke, 8 inches of the remaining material wound around the crossbar were discarded before the next determination. The stretch was not recorded regularly with silk, cotton, and linen as it was insignificant (less than 2 mm. per 100 gm.); whereas, with catgut the variation in the stretch in the same suture was so great than an average could not be arrived at. Four determinations were made on each size suture, except that with catgut, six determinations were made as there were greater variations in the break strength.

To determine the effect of knotting on the different sutures, a square knot was tied in the middle of a straight suture, and in another piece of the same material the free ends were approximated with a square knot and the break strength noted (Table I).

Size for size, dry catgut is the strongest suture material, with silk, linen and cotton following in order. Twisted black silk, which had not been serum-proofed and designated by Manufacturer A as "surgical silk" is 25 per cent stronger than cotton of the same size (Fig. 1).

There is very little difference in the tensile strengths of linen and silk. White mercerized cotton, while only a three-cord thread as compared with the six cords in ordinary thread, has a 10 per cent greater tensile strength, due to the shrinking by mercerization. Following boiling there is 11 per cent increase in the tensile strength of cotton, 15 per cent in linen, and 4 per cent in silk (Fig. 2). Catgut was not subjected to boiling for obvious reasons. Furthermore, it was found

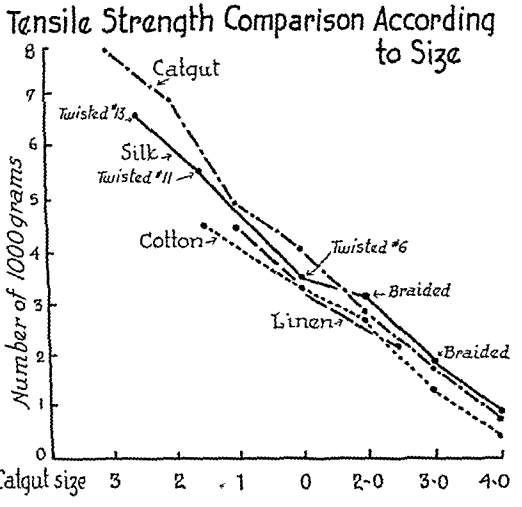


Fig. 1.—Graph illustrating tensile strength of various suture materials according to size.

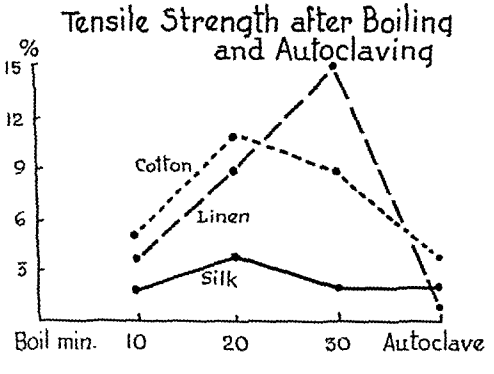


Fig. 2.—Graph illustrating tensile strength of various suture materials after boiling and autoclaving.

from the standpoint of tensile strength that twenty minutes was the optimum length of time for boiling silk and cotton, and thirty minutes for linen (Table I). Steam autoclaving for fifteen minutes at fifteen pounds of pressure, produced little change in the tensile strength of any of the sutures, but any increase in the time and pressure caused a definite decrease in strength. Autoclaving in oil produced a 2 per cent decrease in strength in all sutures. There was less decrease in

TABLE I*

NO.	PHYSICAL STATE OF SUTURE	UNSTERILE	BOILED 10 MIN.	BOILED 20 MIN.	BOILED 30 MIN.	AUTOCLAVED	OIL AUTOCLAVED	IMPLANTATION IN TISSUE			REMARKS
								4 DAYS	7 DAYS	14 DAYS	
12 Cotton	Straight	2050	2135	2245	2175	1930	1860				
	Knotted	1200	1400	1425	1300	1160	1400				
24 Cotton	Straight	1550	1600	1690	1700	1490	1475				
	Knotted	1000	950	1100	1080	1000	1100				
30 Cotton	Straight	1420	1610	1775	1750	1420	1500	1640	1600	1400	
	Knotted	1000	1070	1160	1280	950	1180				
50 Cotton	Straight	880	960	975	940	850	860	925	930	890†	
	Knotted	770	660	670	700	580	770				
60 Cotton	Straight	780	780	810	840	820	720				
	Knotted	660	535	575	575	535	575				
80 Cotton	Straight	720	770	780	780	720	760				
	Knotted	600	480	535	480	500	520				
Mercerized heavy duty	Straight	1360	1375	1360	1320	1360	1300				
	Knotted	1050		960	910	900	970				
20 Mercerized crochet	Straight	2750		2875		2725	2750				
	Knotted	1780		1840		2000	2000				
10 Mercerized crochet	Straight	3420	3500	3550	3500	3550	3475				
	Knotted	2200	2350	2350	2350	2300	2400				
5 Mercerized crochet	Straight	4450	4470	4650	4700	4650	4620				
	Knotted	2720	2700	2750	2800	2600	2700				
30 Black cotton	Straight	1380		1550		1500	1470	1460	1450	1390	
	Knotted	1000		1190		1075	1200				
50 Black cotton	Straight	875		950			880	930	940	910	
	Knotted	690		690			750				
50 Mercerized plain	Straight	1160	1070	1070	1060	1000	1040				
	Knotted	640	650	640	655	555	670				

*All figures in grams.

†In human split graft 18 days; tensile strength, 800 gm.

1 Deknatel silk	Straight Knotted	1850 1270	1950 1250	1920 1300	1850 1250	1920 1270	1800 1300				
2 Deknatel braid silk	Straight Knotted	3150 1900	3350 1960	3220 1950	3120 1900	3270 1920	3150 2350	2450	1900	2100	
6 Twisted silk	Straight Knotted	3000 2050	3150 2100	3150 2150	3000 2000	3200 2250	2950 2300	2370	1650	1700	
9 Twisted silk	Straight Knotted	3500 2375		3600 2400		3650 2400					
18 Twisted silk	Straight Knotted	5500 2900									
15 Twisted silk	Straight Knotted	6500 3900									
60 Linen thread	Straight Knotted	2200 1200	2340 1350	2410 1200	2650 1480	2600 1450	2350 1580				
30 Linen thread	Straight Knotted	4050 2150	4200 2250	4400 2500	4600 2750		4000 2600	3180	2830	2550	
4-0 Chromic catgut	Straight Knotted					915 595		590 (2d)	600(5d)†	340(9d)†	Factory sterilized; 5 cm. stretch before breaking
3-0 Chromic catgut	Straight Knotted					1700 950		900 (2d)	850(5d)	500 (9d)	Factory sterilized
2-0 Chromic catgut	Straight Knotted					2850 1600					Factory sterilized
0 Chromic catgut	Straight Knotted					4050 2350					
1 Chromic catgut	Straight Knotted					4950 3150					
2 Chromic catgut	Straight Knotted					6800 3975					
3 Chromic catgut	Straight Knotted					8100 4800					

the tensile strength of the oil-autoclaved sutures when knotted as compared to steam-sterilized sutures.

As can be seen from the graph (Fig. 3), there is a marked loss in the tensile strength of all sutures when knotted, and, as Taylor[20, 21] has pointed out, aside from the knot itself, that portion of the suture immediately adjacent to the knot is the weakest section and, when tied properly, the suture invariably breaks here. Angulation with

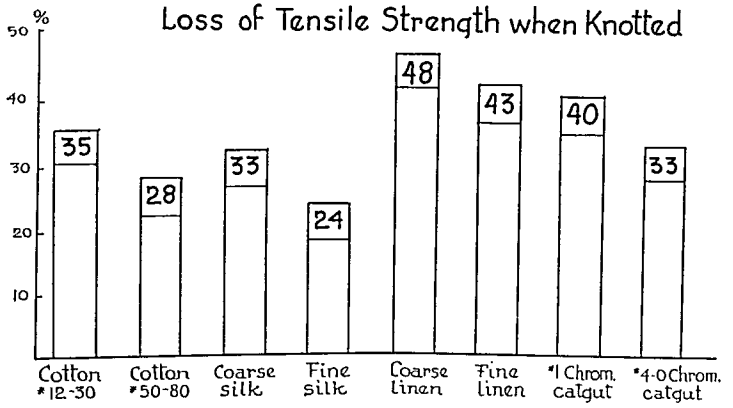


Fig. 3.—Graph illustrating loss of tensile strength of various suture materials when knotted.

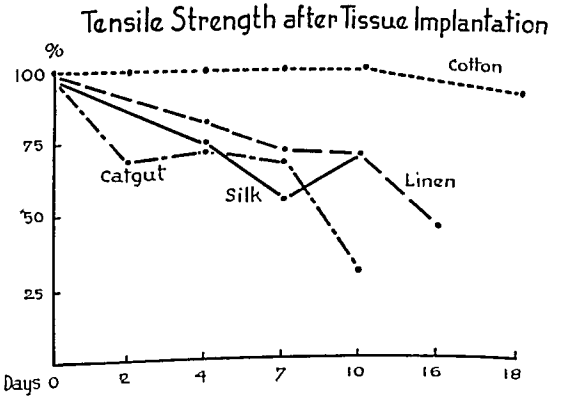


Fig. 4.—Graph illustrating change in tensile strength after tissue implantation.

cracking of the fibers or friction of the sawing action of the two fibers in tying a knot in a catgut suture may so fray the catgut that breaking will occur in that area and not adjacent to the knot. Furthermore, the larger the suture, the greater is the decrease in the tensile strength when knotted (Fig. 3).

The tensile strengths of various suture materials after being placed in tissues were determined. Sutures to be tested were placed under sterile precautions in the fascia and muscles of the anterior abdominal

wall of rabbits and were removed after two, four, seven, ten, and fourteen days respectively. Following removal they showed a decrease in tensile strength, except that the tensile strength of the cotton remained practically the same as that of the original suture (Fig. 4). There was a loss of tensile strength in linen of 21 per cent in four days, 30 per cent in seven days, and 40 per cent in ten days; in chromic catgut 30 per cent in four days, 50 per cent in seven days, and 60 per cent in ten days; in silk 20 per cent in four days, 50 per cent in seven days, and 41 per cent in ten days (Fig. 4). A large number of determinations were made in checking the strength of catgut because there was considerable variation due to stretching (this was not elasticity as there was no return to the original length). Because of the marked stretch of catgut which has been subjected to the action of tissue juices, this suture becomes relatively less efficient than nonabsorbable material. It is obvious, therefore, that not only the relatively greater decrease in tensile strength of catgut subjected to tissue juices, but also the increased stretch of this material make it less desirable as a coaptating suture. It is significant that silk buried in tissue for ten days showed a consistently greater tensile strength, following the initial drop, than that buried for seven days. This increased strength is probably due to the ingrowth of connective tissue into the interstices of the silk.

A cotton suture, No. 50 plain thread, remaining in human tissue (split skin graft) for a period of eighteen days showed only a 10 per cent loss in strength.

Tissue Reaction and Wound Healing.—The tissue reaction, fibroblastic proliferation, and final wound healing were determined as follows: plain, fine, and chromic catgut, fine and coarse silk, fine linen, fine and coarse, plain and mercerized cotton were placed simultaneously in the cutaneous, subcutaneous, fascial, and muscular tissues of the abdominal wall of rabbits and were removed twenty-four, forty-eight, and seventy-two hours, the fifth, eighth, tenth, and thirteenth days after their implantation. All the above mentioned sutures were placed in each rabbit to eliminate variations in individual tissue reaction. Before removal, a gross inspection of the tissue was made and the changes noted. Following removal, the excised wounds were placed in 10 per cent formalin and after the usual preparation were cut and then stained with hematoxylin and eosin.

On gross examination there were insignificant changes before forty-eight hours.

Forty-Eight-Hour Examination.—Catgut: There were moderate inflammatory reactions in the cutaneous tissues about both plain and chromic catgut, the latter being somewhat more pronounced than the former. The edema was much greater than that surrounding silk and

cotton sutures. *Linen:* There were moderate inflammatory reaction, considerable swelling of the suture, and considerable edema. *Silk and Cotton:* There was slight edema, but no gross inflammatory change.

Seventy-Two-Hour Examination.—Catgut: There was some increase in the inflammatory reaction and in the swelling about the suture. *Linen:* There was very little change from the forty-eight-hour reaction. *Silk and Cotton:* There was no noticeable inflammatory reaction or edema.

Fifth Day Examination.—Catgut: There was a decrease in the amount of edema, the inflammatory reaction otherwise remaining the same. In one-half of the animals the peritoneum, although not perforated by the suture, was adherent at the line of suture to the underlying bowel. *Linen:* There was still a moderate amount of edema. The swelling in the suture was about the same as on the third day. *Silk and Cotton:* There was a casing-like projection of fascia up over the suture between the fascia and the skin. There was no inflammatory reaction or edema.

Seventh Day Examination.—Healing had progressed well in the tissue approximated with the catgut and linen; however, there was still some edema about the sutures. Healing appeared much more complete in those tissues approximated with cotton and silk and there was no gross evidence of inflammatory reaction.

Tenth Day Examination.—Catgut was still seen grossly in the tissue and there was a considerably thicker palpable scar about the catgut and linen than about the silk and cotton. There was no gross difference in any of the wounds where plain, mercerized, and black dyed cotton or silk were used.

MICROSCOPIC EXAMINATION

Twenty-Four-Hour Examination (Fig. 5).—*Plain Catgut:* There were marked polynuclear leucocytic and serum reactions in all the tissue layers without penetration of the suture. *Chromic Catgut:* There were marked leucocytic and serum reactions extending deep in the muscle and fascia, somewhat greater in the dermis. *Fine Silk:* There was a moderate polynuclear leucocytic reaction extending from the surrounding tissue into the interstices of the suture, the fibers of which were considerably separated. There was a moderate amount of fibrin present. *Coarse Silk:* The reaction was practically the same as that about the fine silk with proportionate increase in serum and fibrin. There was no evidence of fibroblastic proliferation. Collagen fibrils were absent. *Fine Cotton:* There was moderate polynuclear leucocytic reaction in the surrounding tissue with an occasional polynuclear leucocyte in the peripheral interstices of the suture. The reaction in the dermis was slightly greater than that in the muscle and fascia. There was very

little evidence of serum and *no fibrin*. *Coarse Cotton:* The reaction was indistinguishable from that about the fine cotton. *Mercerized and Black Cotton:* The reaction was also indistinguishable from that of fine cotton. *Linen:* There was marked polynuclear leucocytic infiltration in

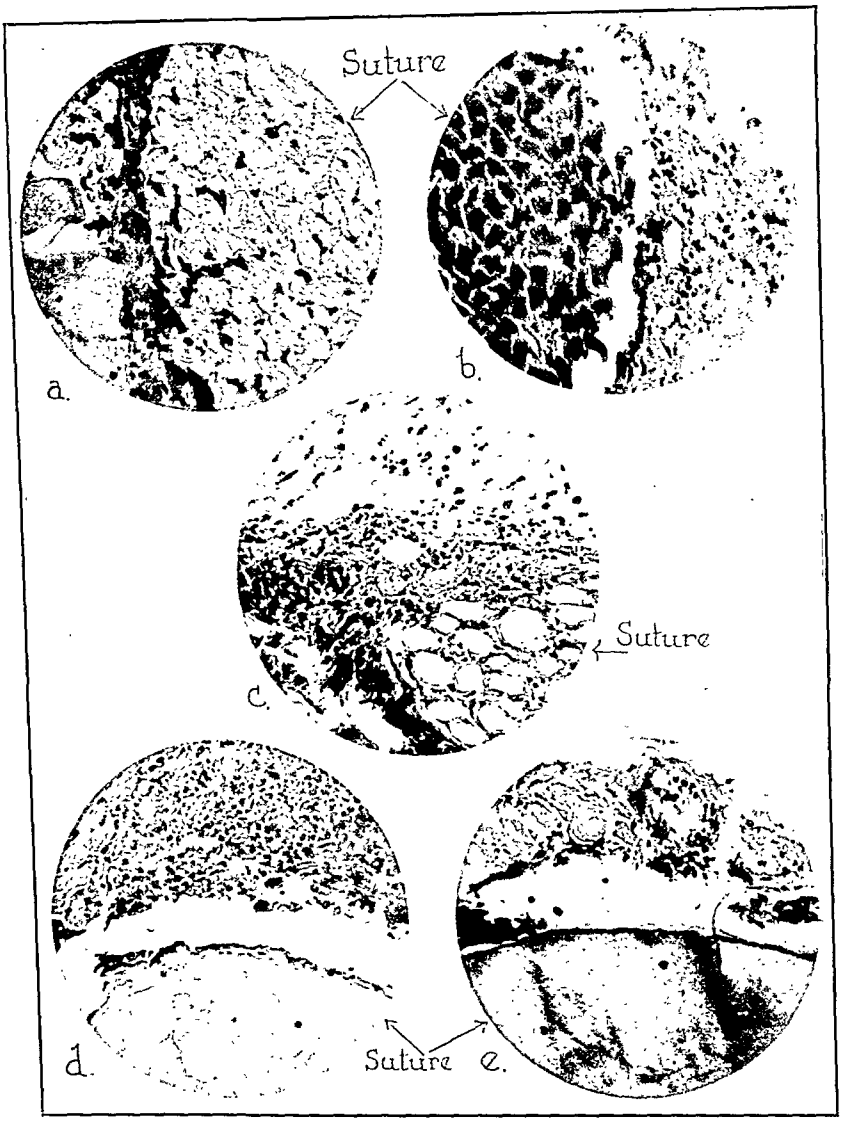


Fig. 5.—Photomicrographs of sutures implanted in tissue (rabbit) for twenty-four hours.

a, Coarse cotton (No. 30); moderate polynuclear leucocytic infiltration of tissue with an occasional polynuclear leucocyte in the interstices of the suture. Small amount of serum present. *b*, Coarse silk (No. 6 twist); moderate polynuclear infiltration of the tissues and the interstices of the suture well filled with polynuclear leucocytes and serum. *c*, Fine linen; marked polynuclear leucocytic infiltration of the tissues and of the interstices of the sutures. Considerable serum present. *d*, Plain catgut (Nos. 3 to 0); marked polynuclear leucocytic infiltration of the tissues, large amount of serum and early fragmentation of the suture. *e*, Chromic catgut (Nos. 4 to 0); marked polynuclear leucocytic infiltration of the tissues with considerable serum present. The suture is homogeneous. There are granulocytes in the vessel.

the surrounding tissue with considerable serum. There was some infiltration of the suture with wandering cells, somewhat more marked at the periphery, and the reaction was considerably greater than that about coarse cotton and silk. The capillaries were filled with polynuclear leucocytes. No collagen fibrils could be seen, but fibrin was present throughout.

Forty-Eight-Hour Examination (Fig. 6).—*Plain Cotton:* There was greater polynuclear leucocytic infiltration than in the twenty-four-hour specimen with small surrounding vessels containing polynuclear leucocytes. The suture was fraying and the polynuclear leucocytes were in the interstices. There was some necrosis with polynuclear leucocytic infiltration particularly marked at the site of cutaneous penetration. No bacteria were visible. *Chromic Catgut:* Due to the marked reaction of the tissue to the catgut, there were adhesions of the gut to the area of suture, although it did not penetrate the peritoneum. There was a marked polynuclear leucocytic infiltration with considerable serum. The blood vessels contained many polynuclear leucocytes. Collagen fibrils were not seen. *Fine Silk:* There was moderate polynuclear leucocytic infiltration in the fascia and muscle. It was somewhat more marked in the dermis. The interstices were filled with neutrophilic polynuclear leucocytes. A few collagen fibrils were present. Bacteria were not visible. Round and plasma cells were occasionally seen. The surrounding tissues were infiltrated somewhat more freely than that about the cotton. *Coarse Silk:* There was moderate polynuclear infiltration, somewhat more prominent than in the twenty-four-hour section and also greater than seen about the fine silk. Collagen fibrils could be seen easily, but were few in numbers. Bacteria were not seen. *Fine Cotton:* There was a very slight increase in the cellular reaction over the twenty-four-hour specimen. The cells were mainly polynuclear leucocytes and were sharply localized about the suture. A few cells were penetrating the interstices of the fibers. Collagen fibrils were prominent and no bacteria were visible. *Black and Mercerized Cotton:* The reaction was indistinguishable from that about the fine cotton suture. *Linen:* The wandering cell reaction was markedly greater than in the twenty-four-hour specimen. Otherwise there was no change.

Seventy-Two-Hour Examination.—Plain Catgut: The cellular reaction extended deep into the tissues. The surrounding blood vessels still contained polynuclear leucocytes, but in the tissues there was about an equal number of round cells. In some areas the suture was somewhat broken up and in others it was still intact. The wandering cells did not extend into it except where the suture had begun to disintegrate. An occasional collagen fibril could be seen, but no fibroblasts could be made out. *Chromic Catgut:* There was an even greater cellular reaction than that about the plain gut with a predominance

of polynuclear leucocytes. There was considerable serum present, but no colonies of bacteria could be seen. The cellular reaction extended for a considerable distance into the surrounding tissues; however, it tended to be less in muscle and loose areolar tissue than in the skin. There was an occasional collagen fibril, but no fibroblastic proliferation could be made out. *Fine Silk:* There was considerable cellular reac-

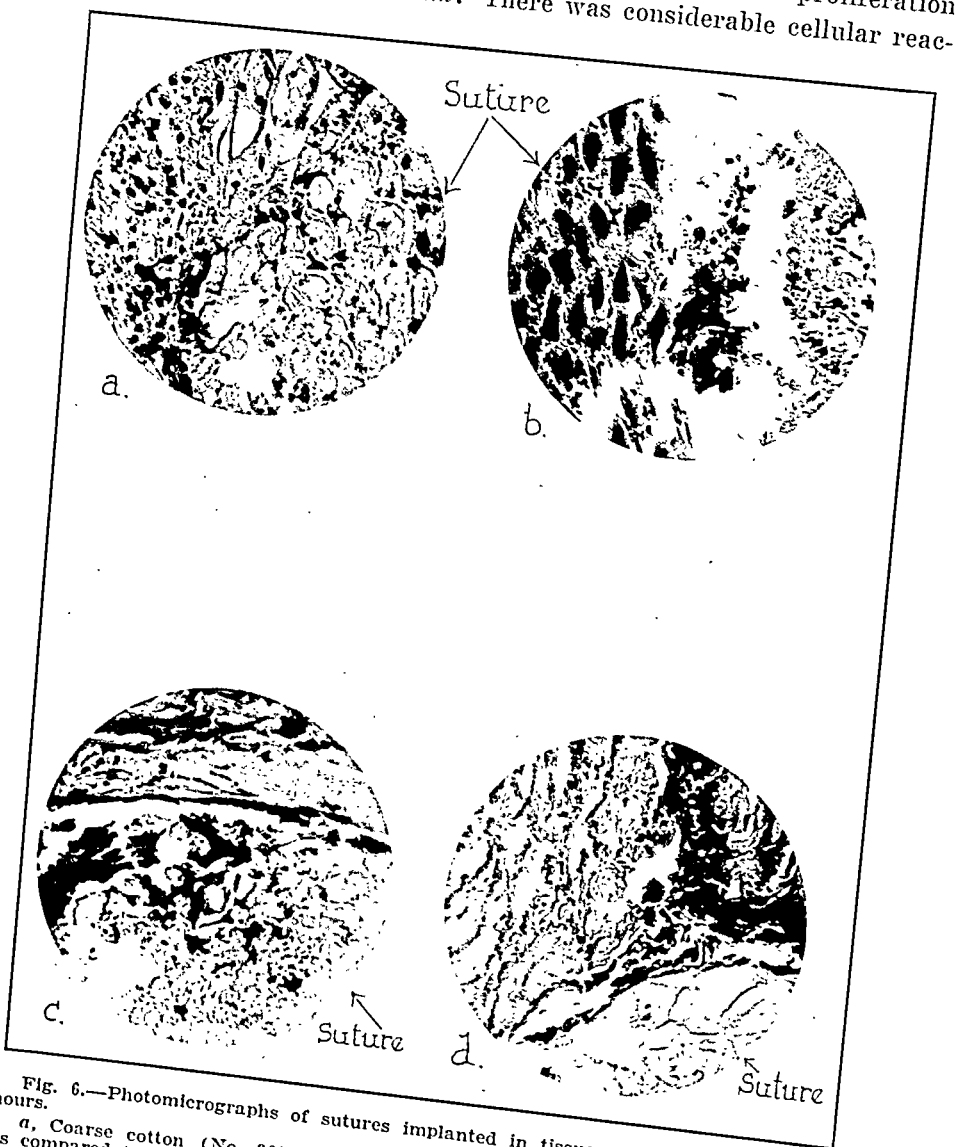


Fig. 6.—Photomicrographs of sutures implanted in tissue (rabbit) for forty-eight hours.

a, Coarse cotton (No. 30); slight increase in polynuclear leucocytic infiltration as compared to the twenty-four-hour specimen. There is a small amount of serum present. A few round cells can be seen. *b*, Coarse silk (No. 6 twist); moderate polynuclear leucocytic infiltration with considerable fibrin and many leucocytes in its interstices. *c*, Fine linen; marked increase in the polynuclear infiltration in tissues and suture with a large amount of serum in the interstices of the suture. *d*, Plain catgut (Nos. 3 to 0); increase in the polynuclear infiltration of tissues as compared with twenty-four-hour specimen. There is continued fragmentation of the suture.

tion and, although the predominant cell was of the round type, there were still many polynuclear leucocytes to be seen in the interstices and at the periphery of the silk. There was a small amount of serum present. Collagen fibrils were numerous and there was beginning fibroblastic proliferation. *Coarse Silk:* There was slightly more reaction than that about the fine silk. There was considerable collagen and serum present. There was a marked decrease in the cellular reaction, the predominant cells being of the plasma and round types. Collagen fibrils were dense and there was beginning fibroblastic development at the periphery. *Coarse Cotton:* There was about the same amount of cellular reaction as with the fine suture, with an occasional polynuclear leucocyte present. Fibroblastic proliferation was well established at the periphery with an occasional projection between the outer layer of cotton fibers. *Black and Mercerized Cotton:* The microscopic picture was indistinguishable from that surrounding the fine cotton. *Linen:* The cellular reaction was about the same as in the forty-eight-hour specimen, with the exception that round cells could be seen occasionally. Collagen fibrils were visible, but no fibroblastic proliferation. There was a considerable amount of serum present.

Fifth Day Examination (Fig. 7).—*Plain Catgut:* There were still areas in which an intact suture could be seen, but, for the most part, the suture was broken up and in the interstices were round cells and polynuclear leucocytes with numerous collagen fibrils present. At the periphery was beginning fibroblastic proliferation with polynuclear leucocytic and round-cell reaction extending well beyond the area of fibrous tissue development. There was a moderate amount of serum present. Bacteria could not be seen. *Chromic Catgut:* The suture was intact in all sections, surrounded by serum and a fairly wide band of polynuclear leucocytic and round-cell infiltration. Collagen fibrils were numerous and fibroblastic proliferation was well established. Occasional polynuclear leucocytes were seen in the vessels. Bacteria were not visible. *Fine Silk:* Many round and plasma cells were still present. There was marked fibroblastic proliferation which not only formed a capsule but had completely isolated each fiber of silk by growing about it. *Coarse Silk:* There was slightly more cellular reaction than that about the fine silk, an occasional polynuclear leucocyte being noted among the scattered plasma and round cells. There was marked fibroblastic proliferation at the periphery and in the interstices of the suture. *Fine Cotton:* The cellular reaction was almost replaced by fibrous tissue, forming a narrow capsule about the suture. There were occasional areas in which this fibrous tissue had penetrated between a few of the cotton fibers at the periphery of the suture. *Coarse Cotton, Mercerized Cotton, and Black Cotton:* There was no appreciable difference from that produced by fine cotton, except that a few plasma and

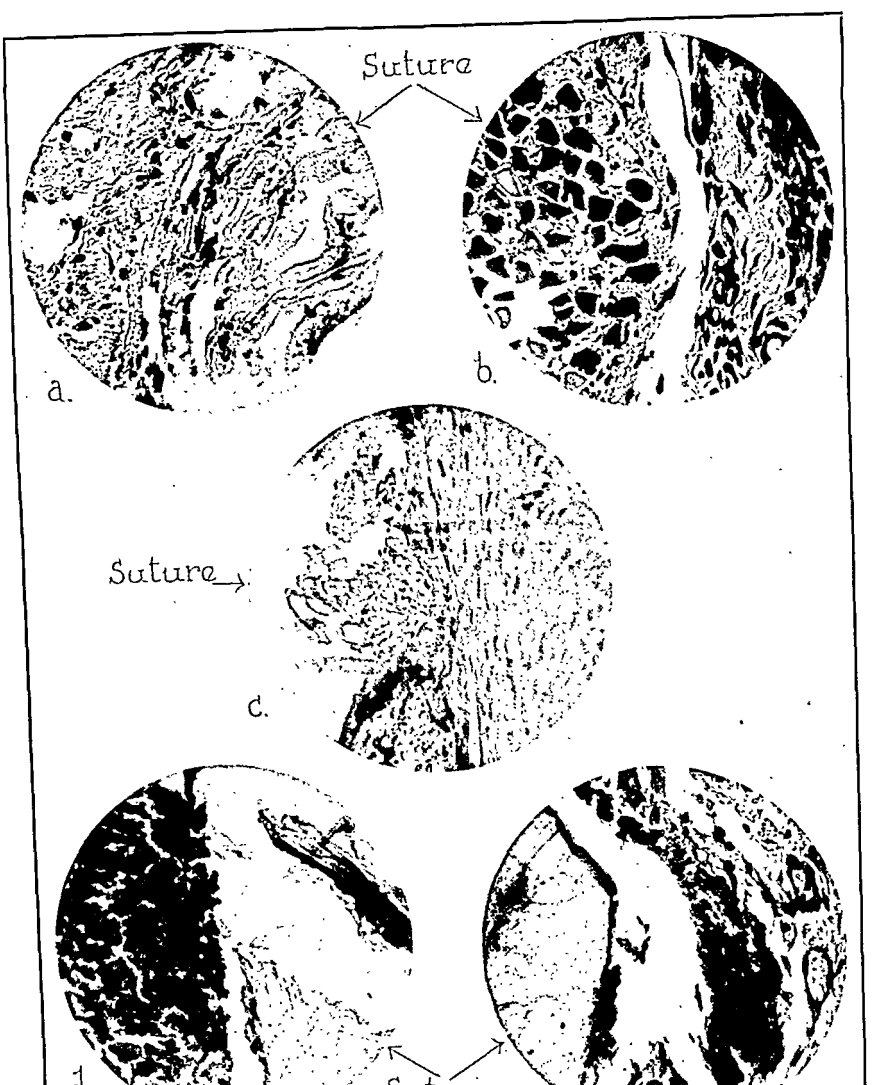


Fig. 7.—Photomicrographs of sutures implanted in tissue (rabbit) for five days. *a*, Coarse cotton (No. 30); an occasional polynuclear leucocyte is seen in the tissue and an occasional round cell in the suture. Growth of tissue into the suture is conspicuously absent. *b*, Coarse silk (No. 6 twist); there is round cell, plasma cell, and polynuclear leucocytic infiltration in the tissue, fibroblastic proliferation with capsule formation. Collagen fibrils and fibroblasts isolate the silk fibrils. *c*, Fine linen; polynuclear infiltration is decreased as compared to the forty-eight-hour specimen. Fibroblastic proliferation with beginning encapsulation of the suture can be seen. There is some penetration of the suture with fibroblasts. *d*, Plain catgut (Nos. 3 to 0); suture is fragmented and there is marked polynuclear infiltration in the surrounding tissue. Fibroblastic proliferation at the periphery is scant. Considerable serum in surrounding tissue. *e*, Chromic catgut (Nos. 4 to 0); the suture is slightly fragmented. There is polynuclear leucocytic and round-cell infiltration of the surrounding tissue with considerable serum present. There is beginning fibroblastic proliferation.

tion and, although the predominant cell was of the round type, there were still many polynuclear leucocytes to be seen in the interstices and at the periphery of the silk. There was a small amount of serum present. Collagen fibrils were numerous and there was beginning fibroblastic proliferation. *Coarse Silk:* There was slightly more reaction than that about the fine silk. There was considerable collagen and serum present. There was a marked decrease in the cellular reaction, the predominant cells being of the plasma and round types. Collagen fibrils were dense and there was beginning fibroblastic development at the periphery. *Coarse Cotton:* There was about the same amount of cellular reaction as with the fine suture, with an occasional polynuclear leucocyte present. Fibroblastic proliferation was well established at the periphery with an occasional projection between the outer layer of cotton fibers. *Black and Mercerized Cotton:* The microscopic picture was indistinguishable from that surrounding the fine cotton. *Linen:* The cellular reaction was about the same as in the forty-eight-hour specimen, with the exception that round cells could be seen occasionally. Collagen fibrils were visible, but no fibroblastic proliferation. There was a considerable amount of serum present.

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siderably broken up. In this fibrous tissue and directly at the periphery of the suture were approximately an equal number of round and polynuclear leucocytic cells. There was a moderate amount of serum present. *Chromic Catgut:* There was a circumferential layer of fibrous tissue about the suture with a moderate cellular reaction predominantly polynuclear leucocytic, extending well outside of the recently laid down fibrous tissue. There was a moderate amount of serum and no bacteria were seen. *Fine Silk:* The entire strand was surrounded by a capsule of fibrous tissue with the fibers of the strand separated by fibroblasts and mature fibrous tissue. There were a few round cells scattered throughout. No serum could be seen. *Coarse Silk:* There was no noticeable difference from that around the fine suture except that the round-cell infiltration was slightly greater. The fibrous capsule was about twice as thick as that seen about coarse cotton. *Fine Cotton:* A circumferential capsule of fibrous tissue, two or four cells thick, surrounded the suture. There was an occasional area in which fibrous tissue had penetrated the suture. *Coarse, Mercerized, and Black Cotton:* There was no noticeable difference from that of fine cotton. *Linen:* Whereas there was considerable cellular reaction still present in the form of both polynuclear leucocytes and round cells, there was a large amount of fibrous tissue present. A small amount of serum could be seen in and about the suture. No bacteria could be seen.

Thirteenth Day Examination (Fig. 9).—*Plain Catgut:* The broken-up catgut still had an elliptical form, but it had lost its homogeneous appearance. It was surrounded by fibrous tissue which contained round and plasma cells. There was very little tendency for the fibrous tissue to infiltrate the interstices of the disintegrated gut. There was still some serum present. No bacteria were seen. The area of fibrous tissue reaction was considerably greater than with either silk or cotton. *Chromic Catgut:* There were longitudinal, parallel cracks in the suture. At the periphery of the suture was a fibrous tissue reaction two or three times as great as that with silk and four times as great as that with cotton. A few polynuclear leucocytes and round cells were still present. There was some tendency for the fibrous tissue to penetrate the suture at its periphery. *Fine Silk:* The suture was surrounded by a thin circumferential capsule of fibrous tissue (slightly wider than that about the cotton) and the silk fibers were widely separated by invading fibrous tissue. However, there were some areas in which serum was still present with an occasional round cell in the interstices of the silk suture. *Coarse Silk:* There was little difference in the microscopic appearance as compared with that produced by fine silk, except that a few more round and plasma cells were present, and the circumferential capsule was thicker in the fine silk. *Fine Cotton:* There was a very thin circumferential capsule of fibrous tissue about the cotton suture. This fibrous tissue extended into the cotton in an

round cells could be seen in the fibrous tissue about the coarse cotton. *Linen:* There was a decrease in the cellular reaction in the surrounding tissue with an increase in the number of round cells. There was still a small amount of serum present, numerous fibroblasts, and a beginning circumferential deposition of fibrous tissue.

Eighth Day Examination (Fig. 8).—*Plain Catgut:* There was a circumferential layer of fibrous tissue around the suture which was con-

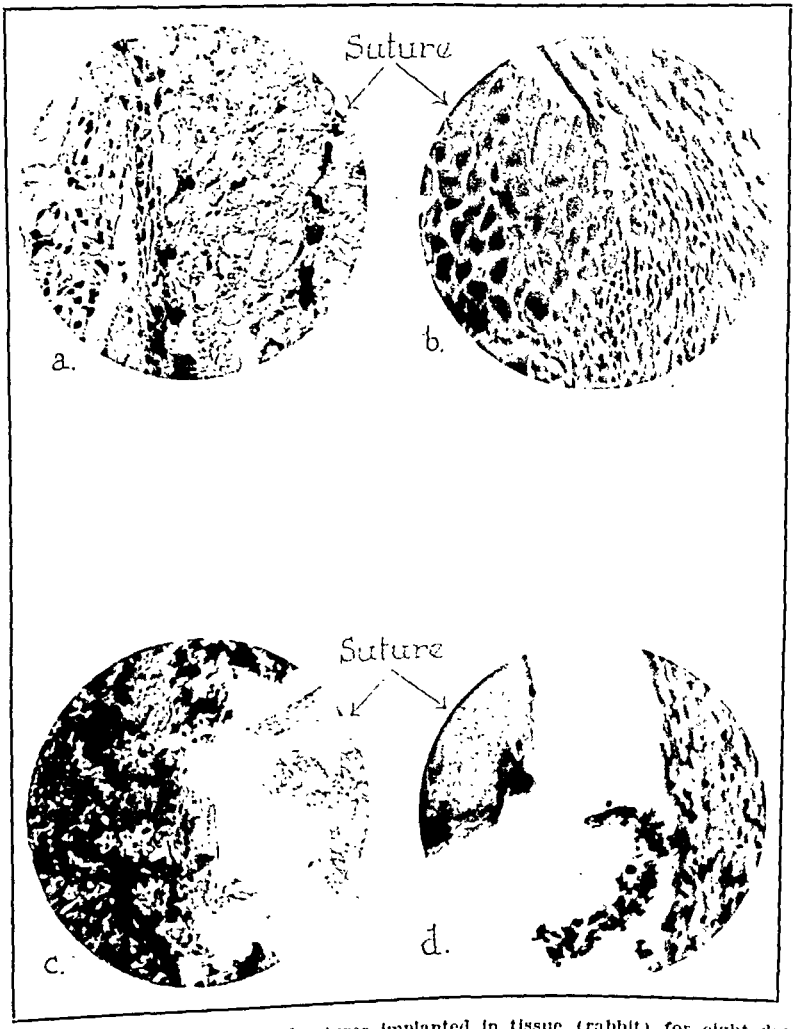


Fig. 8.—Photomicrographs of sutures implanted in tissue (rabbit) for eight days. *a*, Coarse cotton (No. 30): a few round cells are seen in the tissue and in the suture. A narrow fibrous capsule without any growth into the suture is well demonstrated. *b*, Coarse silk (No. 6 twist): round cells are present in the tissue and between the silk fibrils. Fibrous tissue throughout the suture is continuous with the fibrous capsule. *c*, Plain catgut (Nos. 3 to 0): there is marked fragmentation of the suture and mixed-cell infiltration is still rather marked in the newly formed fibrous tissue. *d*, Chromic catgut (Nos. 4 to 0): mixed polynuclear and round-cell infiltration in the newly formed fibrous tissue and the suture shows only slight fragmentation.

nique in preparing the tissues. *Coarse Cotton:* The only noticeable difference in the microscopic appearance, as compared with that produced by the fine cotton, was that the fibrous capsule was slightly thicker in the former. *Black and Mercerized Cotton:* The microscopic appearance was the same as that produced by plain cotton. *Linen:* There was still a considerable amount of cellular reaction with fibrosis being more advanced than at ten days. There was no evidence of bacteria.

A gastrojejunal anastomosis in a dog performed with fine cotton, No. 50, at the end of ten days showed, on gross examination, that on the peritoneal side the junction was completely covered by serosa and no suture material could be seen. The mucosal surface was smooth, pink, and without any areas of congestion, hemorrhage, or ulceration. The cotton suture could not be seen. Microscopic examination showed that the hemostatic suture was surrounded by a marked fibroblastic reaction seven to ten cells in width. This tissue had a moderate round-cell infiltration and an occasional polynuclear cell. There was no evidence of the cotton being invaded by the fibroblasts. When the suture penetrated the muscular coat, there was less fibroblastic and wandering cell reaction with an occasional strand of fibrous tissue in the suture. Here also the fibrous capsule was extremely thin and was laid down circumferentially. Near one area of the mucosal suture was a focal abscess. This did not change the size or appearance of the cotton and the fibers were not penetrated by polynuclears and apparently the suture had no direct relation to the abscess. Where the suture was cut longitudinally, it could be readily seen that, whereas there was a thin capsule of fibrous tissue, the main body of the suture did not contain any. The suture on the serosal side had a capsule of fibrous tissue similar to that in the muscle and here also the cellular reaction was much less than when the suture pierced the mucosa and submucosa.

Serum-proofed, braided silk could not be distinguished from twisted plain silk either from its appearance or from the surrounding cellular reaction. There was questionable swelling of the plain silk fibril as compared with the serum-proofed silk, but the fibrous tissue ingrowth was as great in one as in the other.

BACTERIOLOGY

The organisms which are found in catgut have previously been referred to and a comprehensive study of the bacteriology of catgut has been made by Bulloch and co-workers, Meleney and Chatfield, and Clock.[6, 10-12] These investigators not infrequently found pathogenic anaerobes in the substance of sterilized catgut.

In the present investigation the ordinary pyogens were destroyed (in silk, thirty samples; in linen, thirty samples; and in cotton, forty-four samples) by heating beef-broth culture of the suture material to

occasional area but not deeper than one fibril of cotton. There was slight shrinkage in the size of the cotton compared to the fifth day specimens. This might have been due to some variation in the tech-

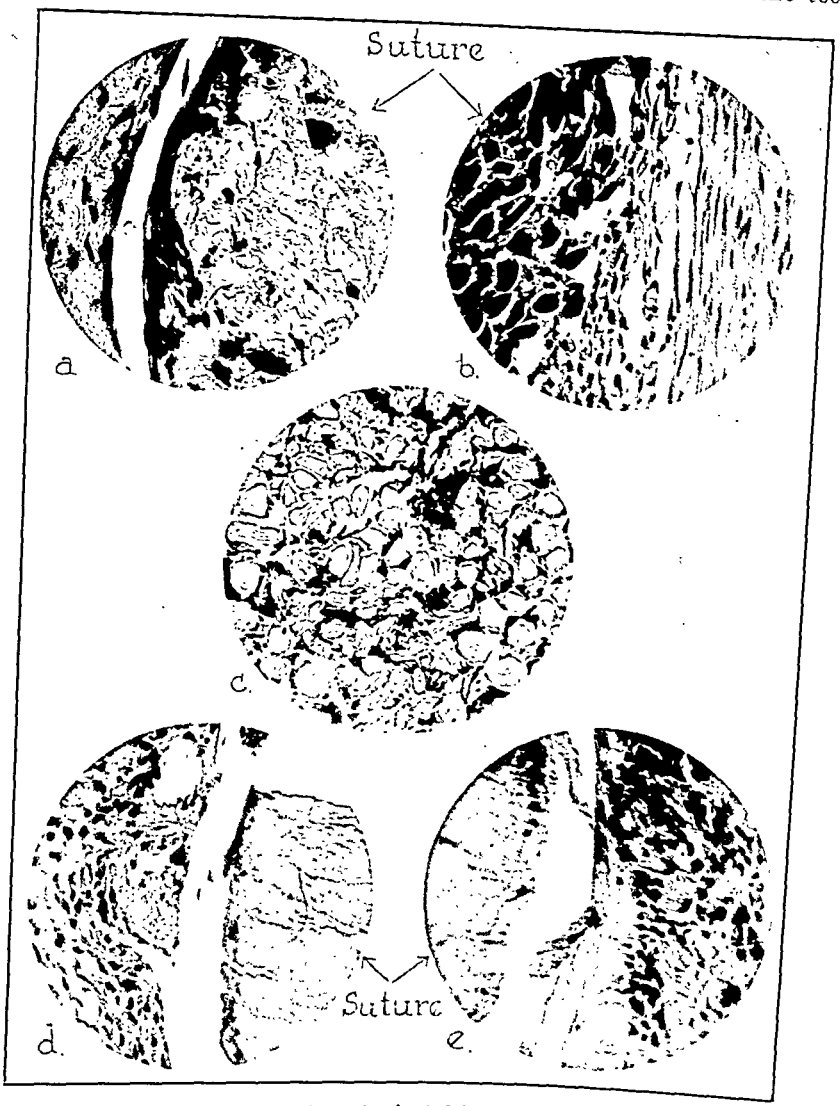


Fig. 9.—Photomicrographs of sutures implanted in tissue (rabbit) for thirteen days. *a*, Coarse cotton (No. 30); a circumferential fibrous capsule is present without growth of tissue into suture. No wandering cells present. *b*, Coarse silk (No. 6 twist); the circumferential fibrous capsule is continuous with fibrous tissue in the suture, which has isolated each silk fibril. There are a few round cells in the interstices of the suture. This microscopic picture could not be distinguished from that of serum-proofed silk. *c*, Fine linen; there are numerous round cells in the interstices of the suture with a few strands of fibrous tissue unevenly distributed throughout. *d*, Plain catgut (Nos. 3 to 0); the fragmented suture is surrounded by fibrous tissue which still contains a little serum, round and plasma cells. The fibrous tissue is gradually replacing the suture. *e*, Chromic catgut (Nos. 4 to 0); the suture is fragmented only at its periphery and is surrounded by fibrous tissue in which are some round and polynuclear leucocytes and some serum. Healing is not complete until all of the catgut is digested and absorbed.

silk. At the end of thirteen days there was complete healing and no evidence of inflammatory reaction when the wound was closed with silk; whereas, wounds closed with catgut showed inflammatory reaction as long as the catgut was present, which was generally from nineteen to twenty-three days (chromic catgut). Equally important was the fact that catgut interfered with wound healing because of the later appearance of fibroblasts (catgut five days, silk three days). When the wounds were closed with cotton, the tissue reaction was least, in that there was less inflammatory reaction and the appearance of the fibroblasts was earlier (fibroblastic proliferation was evident twenty-four hours earlier in wounds closed with cotton than with silk). Whereas all inflammatory reaction had entirely subsided in thirteen days in silk-closed wounds, inflammatory reaction occurred as early as ten days in those closed with cotton.

As previously mentioned, it is generally assumed that nonabsorbable sutures produce minimal tissue reaction and therefore are preferable to absorbable ones. This assumption is substantiated by our investigation with silk and cotton. On the other hand, linen, which has been used surgically for a much longer period of time, produces a much greater reaction than silk and cotton, and up until the fifth day has almost as great reaction as catgut. From the fifth to the tenth days the cellular reaction to linen slowly diminishes until at the end of that time (ten days) the reaction is only slightly more than that of silk and cotton (Fig. 10).

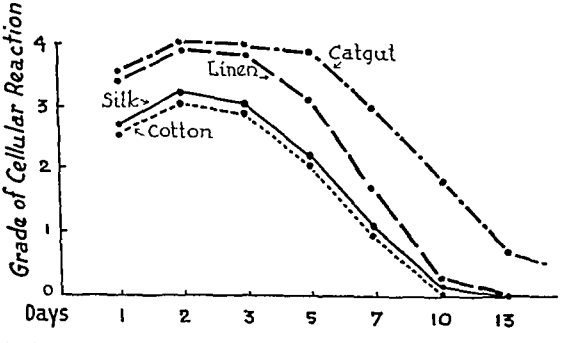


Fig. 10.—Graph illustrating the differential in cellular reaction of various suture materials.

Microscopically there were obvious differences in and about silk and cotton sutures used to close the wounds. In the former (twisted and braided), there is wide separation of suture fibrils, first by serum and wandering cells and later by fibroblasts. In the latter, because of the natural twist of the cotton fibrils, maintaining a compact suture even after insertion in the wound, there is minimal separation of the fibrils and practically no tissue ingrowth. These differences are of little significance in clean wounds but may be of great importance in the presence of infection as granulation tissue invading the interstices of the

60° C. for one hour on two successive days. The broth was then incubated for twenty-four hours and subcultures made. The original cultures were then made anaerobic by overlaying the media with three-quarters inch of vaseline. These were then incubated for fifteen days. No growth was obtained from the subcultures and no anaerobic growth in the broth containing silk. However, in five specimens of linen and four specimens of cotton there was found a motile, gram-positive, chain-forming, nongas-producing, strictly anaerobic organism which was found to be proteolytic and which we believe to be either *Bacillus histolyticus* or a similar organism.

Following boiling of linen and cotton for ten minutes, the above type of anaerobe was found to be present in 7 per cent; whereas, all those boiled for twenty minutes were sterile. When samples from the same series were autoclaved for fifteen minutes at fifteen pounds pressure, growth occurred in three of forty-four (6.8 per cent) specimens of cotton and linen. This growth may be due to a factor which has previously been referred to by Goris.[35] Goris showed that, when stoppers made of cotton were placed in tubes containing suture material, these prevented thorough sterilization, both when a temperature of 120° C. for one hour was used and when 130° C. for thirty minutes was used. However, with the tubes open, using the same lengths of time and temperatures, all suture material became sterile. As we used plugs in our tubes, these probably were responsible for the presence of organisms following autoclaving. On repeating the autoclaving of linen and cotton suture material in open-mouthed tubes, sterility was established in 100 per cent.

Whereas anaerobic organisms were demonstrated in both linen and cotton, they were not pathogens, but we believe that it is possible for both tetanus and gas bacilli to be present in these two materials and further investigation is being carried out with this in mind. Silk, apparently, does not contain anaerobic organisms but only the ordinary pathogenic aerobes. This last material will also have further study from the standpoint of its bacteriology.

COMMENT

Absorbable sutures produce essentially a wet reaction in tissues, which is an attempt on the part of the host to digest the suture by means of proteolytic ferments derived from leucocytes. This wet reaction consists of excessive fluid and cellular exudation which is associated with a concomitant delay in the appearance of fibroblasts. Both of these factors deter wound healing. On the other hand, it has been demonstrated that nonabsorbable suture produces a minimum amount of exudation (dry reaction) and that fibroblastic proliferation begins early. The results of our investigations corroborate the observations of Howes and Harvey[14] as regards the tissue reaction to catgut and

surfaces by suture results in an increase in the tensile strength of the suture by one-third when the knot has been made. After completion of the knot, the wound edges are held by a double strand, one in which the knot is located and the other intact strand. By tensile strength determination, we have demonstrated that such a suture is 35 per cent stronger than a straight unknotted strand.

Whereas wound healing occurs best in the absence of infection and when nonabsorbable sutures are used, many fear the use of nonabsorbable sutures in the presence of contamination because of the foreign body which is believed to predispose to sinus formation. Although occasionally in the presence of infection a sinus occurs which will persist until the silk suture is extruded or removed, infection of contaminated wounds closed with silk is much less likely to occur than in similar wounds closed with catgut. Although our experience with cotton is not yet as extensive as that with silk and catgut, we are of the definite opinion that sinus formation is even less likely than with silk. We have seen severely infected wounds in which cotton has been used throughout, heal without sinus formation and without extrusion of the cotton. Whereas the use of silk sutures in strictly clean cases results in very early healing and little reaction as shown by the experience of those who have used it, we believe, contrary to the opinion of most of its advocates, that the most important use of nonabsorbable sutures is in the grossly contaminated wounds. This contention, at variance with those of others, is based upon the experience that the grossly contaminated abdominal wound closed with catgut is particularly likely to disrupt, probably because of two factors: (1) delay in wound healing because of the infection, and (2) early digestion of the suture material by the large amount of proteolytic ferment liberated from the leucocytes. In such an instance the coaptating suture becomes valueless before wound healing has been completed, or, in some instances, even started. If, however, a nonabsorbable suture, particularly cotton, is used, the wound is held intact until the infection has subsided and complete healing has occurred.

Irrespective of one's belief concerning the relative values of absorbable and nonabsorbable sutures, one cannot deny that strictly clean operations, such as mammectomies, thyroidectomies, and herniorrhaphies, in which only nonabsorbable sutures are used, are followed by much less reaction, absence of serum, and earlier healing than in those in which absorbable material is used. Prior to the use of nonabsorbable sutures, we were never able to close thyroidectomy or mammectomy wounds, in both of which many ligatures are placed, without drainage because of the invariable accumulation of serum. Since the use of nonabsorbable sutures (silk and cotton), drainage has not been used in these cases and healing has occurred promptly without serum ac-

silk may prolong the infection and may be responsible for the occasional draining sinus in wounds closed with silk. Although this will account for the occasional persistent sinus in silk-closed wounds, contrary to the general opinion contaminated wounds closed with silk are much less likely to become infected than those closed with catgut and usually heal by primary intention.

As Halsted[4] originally stated and as more recently emphasized by Howes, it is unnecessary to use a suture material stronger than the tissues coaptated. Generally, fine sutures should be used because not only is a heavy suture frequently unnecessary, but it is actually harmful because it permits by virtue of its increased strength greater tension, mass ligation, and strangulation.

As originally emphasized by Halsted,[4] silk should be used as interrupted sutures. Our experience substantiates this contention. Early in our use of nonabsorbable material continuous sutures were used in the fascia and peritoneum, which resulted in two cases of persistent, progressive inflammatory reaction associated with marked fibrous tissue proliferation (Schloffer's tumor). Both of these resisted therapy until the tumors, which extended down to and included the peritoneum, were excised. Closure of these wounds with interrupted silk resulted in prompt healing. Because of the fibrous tissue capsule surrounding the silk suture and because of the possibility of infection extending along the course of the silk suture resulting in persistent and multiple sinuses, the use of continuous silk sutures is to be condemned. Although cotton produces less reaction than silk, it is still nonabsorbable and therefore only interrupted sutures should be used and these should be of as small diameter as possible. Whereas Howes has recently advocated the use of catgut in this same way, we believe that the excessive number of relatively large knots and the necessity of cutting the suture long to prevent the knot from untying will produce enough increased inflammatory reaction in the wound to offset any possible advantage gained.

Halsted advocated that silk sutures be cut "on the knot" because there is little likelihood of the knot's becoming untied in contradistinction to catgut, and because of the undesirability of leaving a long piece of silk in the wound. As Taylor[20, 21] has recently demonstrated, serum-proofed braided silk sutures, when cut immediately "on the knot," are likely to become loosened under tension when a square knot is used; but, when a triple throw knot is used, it may be cut on the knot. Our experience with cotton shows that the suture can be cut closer to the knot than when using silk. This is due to the fact that cotton, not being serum-proofed, has a higher frictional coefficient as Taylor showed to be true in silk which had not been serum-proofed.

As mentioned above, the tensile strength of a suture is decreased by the presence of a knot (Fig. 3). Actually the coaptation of wound

3. While silk and linen show early decrease in tensile strength as compared to cotton, they also are somewhat stronger before being implanted in tissue.

4. Cotton and linen, as products of the field, may contain spore-forming anaerobic pathogens, but the average threads obtained on the market have not contained any pathogenic organisms. Silk contains the ordinary pyogens, but anaerobic organisms were not found.

5. Chemically treated silk and catgut are proteins, but the former is nonabsorbable and excites much less tissue reaction.

6. Silk wounds in the presence of an infection (not contamination) may develop sinuses which will not heal until the suture is removed or is expelled because of the presence of infected granulation tissue in the silk itself.

7. There is little difference in the wound healing when serum-proofed and nonserum-proofed silk is used.

8. Braided silk has greater tensile strength than twisted silk.

9. Cotton shows much less tendency for tissue ingrowth and is therefore less likely to cause sinuses in the presence of infection than silk. (Three cases that were infected have healed without sinus formation.)

10. Cotton is proposed as a pliable, easily sterilized, nonirritating, inexpensive suture of sufficient strength in the recommended sizes for most surgical procedures. It has been used in ninety-one surgical procedures, primary healing taking place in eighty-eight cases.

11. Halsted's silk technique is recommended not only for silk, but also for cotton.

12. The reaction of tissue to the implanted suture was graded according to the amount and persistence of leucocytic infiltration, amount of serum and fibrin, the appearance time of fibroblasts, and length of time necessary to produce final healing. Accordingly catgut, by producing the most reaction and slowest healing, was graded 4; linen, 3; silk, 2; and cotton, producing the least reaction and earliest healing, was graded 1 (Fig. 10).

The authors appreciate the technical assistance of Miss Edith Honold and Miss Mary Elizabeth Davenport.

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cumulation. It should be emphasized, however, that marine sponge compression dressings are used almost routinely.

From a technical standpoint, it is easy in closing laparotomy wounds to insert all the sutures in a layer before tying, as in this way the wound tension can be transmitted to all the sutures and also time is actually saved.

Up to the present, cotton has been used throughout the operation in ninety-one patients. All wounds except three have healed by primary intention; two of these were infected at the time of operation and the other was in an old scar, the previous wound having been drained at the time of operation two years before. It has been used in colostomies, repair of hernias, thyroidectomies, radical and simple mastectomies, cholecystectomies, perforated ulcers of stomach and duodenum, repair of episiotomy wound, repair of tendon, suturing of split skin graft, purse-string sutures in appendectomies, ligation of external carotid, gastrectomies, and pneumonectomies.

Cotton, size for size, is two-thirds as strong as catgut and three-fourths as strong as silk. The mercerized cotton is 15 per cent stronger than plain cotton, but, when used under tension, should always have a triple throw knot placed in it as its frictional coefficient is less than that of plain cotton. However, cotton maintains its original tensile strength longer than catgut, linen, or silk (Fig. 4).

In the use of cotton, as in all other sutures, it is desirable that as fine a suture as possible be used. It is recommended that for ligatures on small vessels of the subcutaneous fat and other areas, No. 60 plain cotton be used and that No. 30 plain cotton or "heavy duty" mercerized cotton be used for approximation of the peritoneum and fascia. Where the so-called retention sutures are to be employed, No. 20 crochet cotton can be used. For through-and-through sutures of the abdominal wall, No. 10 mercerized crochet cotton is best. For skin closure, it is better to use black cotton, because the white is somewhat difficult to find at times due to its becoming stained with blood.

CONCLUSIONS

1. Catgut has been demonstrated to be (a) a strong suture before being placed in tissue; (b) absorbed at a variable rate which depends on its size, the chemicals present, and the reaction of the individual in which it is placed; (c) a possible source of allergic reactions; (d) a deterrent in wound healing; (e) unreliable when knotted under tension unless a triple or quadruple throw knot is tied; and (f) above all, a possible cause of wound infection.

2. Nonabsorbable suture materials: (a) can always be heat sterilized; (b) produce no allergic reactions; (c) allow rapid wound healing; (d) allow reliable square knots to be tied.

PERSISTENT ABDOMINAL FECAL FISTULAS DUE TO REGIONAL ILEITIS

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CLINICAL studies on the subject of regional ileitis have been so frequent in the last few years that another article on this subject should, perhaps, be prefaced by an apology. The justification for the present communication is that it is a more intensive study of one of the particular phases of this disease than has yet appeared. Judging from the late stages in which these patients are still being seen, this particular complication of the disease seems to be the least recognized of all the manifestations of regional ileitis. The cases of regional ileitis which constitute the subject of this study are characterized by the presence of chronic intractable fecal fistulas originating, as a rule, in the terminal ileum. They developed, usually, following appendectomy or the drainage of ileocecal abscesses supposedly of appendical origin. A review of all the cases of fecal fistulas operated upon at the Mount Sinai Hospital since 1927 (Table I) shows that these constitute a large proportion of all cases of chronic fecal fistulas, that they are indubitably due to regional ileitis and not to appendicitis or tuberculosis with which they were formerly confused, and that their chronicity and intractability

TABLE I

CAUSES OF FECAL FISTULAS AT MOUNT SINAI HOSPITAL (1927-1939)*

1. Regional ileitis		14
2. Appendicitis		21
a. Primary operation at Mt. Sinai Hospital	16	
13 closed spontaneously		
3 required operative closure		
b. Primary operation elsewhere	5	
4 lip fistulas		
1 multiple perforation of small intestine		
3. Actinomycosis		4
4. Perforated carcinoma		2
5. Regional colitis		1
6. Tuberculous salpingitis		3
7. Tuberculous peritonitis		1
8. Tuberculous appendicitis		1
9. Tuberculosis of intestines		1
10. Tuberculous colitis		1
11. Diseased adnexae and abscess		2
12. Uterine and adnexal operation		8
13. Perforated sigmoid diverticula		2
14. Sliding hernia of sigmoid		1

*Fistulas subsequent to operative procedures upon the bowel are not included.

Received for publication, September 14, 1939.

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along these lines is furnished in the case of two patients dying prior to operation, upon whom post-mortem examinations were performed. In these, two large right lower quadrant abscesses were found arising from perforations in the terminal ileum which were the seat of a typical ulcerative cicatrizing enteritis. The appendices in both these cases were normal.

2. Regional ileitis has a marked tendency toward perforation.

This is evidenced by the high incidence of spontaneous enterocolic fistulas, intramesenteric abscesses, and sealed-off intra-abdominal abscesses accidentally encountered at operation for the enteric or obstructive type of the disease.

3. The pathologic changes in segments of bowel, the seat of fistulas due to regional ileitis, and those where the fistulas are definitely due to appendicitis are quite different.

In cases where the intestinal fistulas have developed as a result of extrinsic factors, such as peri-intestinal suppuration, inflamed bowel wall, pressure of drainage material following operation for appendicitis, the changes in the involved portion of bowel are limited rather sharply to the region of the internal opening or openings. Although the adjacent serosa may show evidence of chronic inflammation, the mucosa and submucosa show no evidence of any ulceration or hypertrophy. In regional ileitis, however, where the perforation is due to intrinsic disease of the bowel wall, pathologic alterations are not limited to the region of the perforation, but involve an entire segment. These pathologic changes may be as marked at an area some distance from the perforation as at the point itself. It may further be noted that a common occurrence in fistulas due to regional ileitis is the finding of tracts running between the leaves of the mesentery having the internal opening at the mesenteric border (Fig. 3). This is easily explained by the fact that in regional ileitis ulcerations on the mesenteric border of the bowel are frequent. It would be difficult to explain how appendicitis could cause a fistula originating in this particular section of the bowel.

4. Persistent fecal fistulas following acute appendicitis are relatively uncommon.

From the evidence gathered in this institution it would appear that in spite of the great frequency of acute appendicitis chronic fecal fistulas are an uncommon complication. Attention was directed to this feature from another standpoint by Colp.[2] In a study of 2,840 cases of acute appendicitis on the wards of the Mount Sinai Hospital, he found only 33 instances of postoperative fecal fistulas, or 1.1 per cent. Of these, only 3 required operation. During the past ten years, approximately 2,900 cases of acute appendicitis were operated upon on the ward service of this institution (fatal cases are not included). Postoperative fecal fistulas developed in 16 of these, only 3 of which failed to close spontaneously.

are due to a large extent to the failure to appreciate that they are complications of an underlying intestinal disease.

Regional ileitis either begins as, or rapidly becomes, an ulcerative disease. The type of clinical course which will dominate the picture of the disease is determined to a large extent by the future course of these ulcers. They may remain relatively superficial and the inflammatory and proliferative reactions which they incite may remain chiefly intramural. In such instances the symptoms which develop are the result of changes limited to the bowel wall and are either enteric or obstructive in character. In other cases penetration or slow perforation of these ulcers tends to occur. The serosal layers of the bowel become involved and a picture of peritoneal inflammation is produced. Actual perforation either into previously sealed-off portions of the abdominal cavity or between the leaves of the mesentery produces signs of localized intraperitoneal suppuration and abscess formation. The introduction of drainage material into such an abscess, already communicating with diseased bowel, almost inevitably produces a fecal fistula. It must be emphasized that there is not necessarily any parallelism between the intramural and perforating aspects of the disease, nor is perforation necessarily a late stage. In this respect the course may be compared to that of peptic ulcer where perforation may be the earliest symptom, may occur at any stage, or may never occur at all.

Inasmuch as the terminal ileum is the portion of bowel usually involved in this ulcerative process, it is evident that for topographical reasons the local signs and symptoms produced closely resemble those of acute appendicitis. As appendicitis is by far the most common cause of acute infection in the right lower quadrant, it is natural that such sequelae of suppuration as fistulas should be primarily considered a complication of disease of the appendix. The number of such chronic cases which we have encountered has persisted as such largely because of this point of view. It might be of interest to record the reasons for our own change of viewpoint with respect to the problems of such chronic intestinal fistulas.

1. It is unnecessary to postulate an acute appendicitis either for the production of regional ileitis in general or the type with fistula formation in particular.

In our original series of regional ileitis[1] it was noted that, in those cases where a prior appendectomy had not been performed, typical intestinal lesions were found with normal appendices. In addition, three further cases of abscess and persistent fecal fistulas which had previously been subjected to multiple operations may be cited. The fistulas had been definitely attributed to appendicitis by various operators, but eventual resection revealed normal appendices still in situ with fistulas originating in diseased terminal ileum. Further evidence

along these lines is furnished in the case of two patients dying prior to operation, upon whom post-mortem examinations were performed. In these, two large right lower quadrant abscesses were found arising from perforations in the terminal ileum which were the seat of a typical ulcerative cicatrizing enteritis. The appendices in both these cases were normal.

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5. The clinical behavior of fistulas due to acute appendicitis and of those due to regional ileitis are different.

The clinical characteristics of fecal fistulas definitely due to acute appendicitis are the following. They seem to follow the severer types of the disease. They appear within the first few weeks postoperatively and usually close spontaneously. When spontaneous closure occurs, it is apparently permanent. When the fistula persists, some obvious cause can usually be found, such as lip fistulas, prolapse of cecum, or distal obstruction. Thus, of the 16 cases of fecal fistulas following acute appendicitis in the second series mentioned above, 13 closed spontaneously. Of these, 9 healed within a month of their first appearance. The remaining 4 closed within periods of two to six months. Once they had closed there was no further recurrence. Only 3 of the 16 cases of fecal fistulas required operative closure. Two of these were lip fistulas, one of the ileum and the other of a perforated angulated appendix which prolapsed into the wound following drainage of an appendix abscess. In the third case an abscess had dissected subserosally along the cecum so that normal healing of the appendix stump was probably interfered with.

There was another group of 5 cases in which the primary appendectomy for proved acute appendicitis had been performed elsewhere and who applied at this institution for treatment of their fecal fistulas. In 4 out of 5 the persistence was definitely due to lip fistulas. The fifth case is of considerable importance and interest. It is the only case in this series in which continued suppuration and fecal discharge following operation for bona fida acute appendicitis was maintained by communications with ulcerations in the small intestine without any mechanical or obstructive factor to account for such persistence. This patient had originally been operated upon for perforated appendicitis with abscess lying mesially and completely surrounded by coils of small bowel. For months she continued to show evidences of extending intra-abdominal suppuration and fecal fistulas, finally dying from progression of the infection in spite of attempts to furnish adequate drainage. As a matter of fact, it was thought that the patient was probably suffering from regional ileitis. Autopsy revealed abscess cavities between loops of terminal ileum. In one of these loops there were a number of small perforations which communicated with the abscesses. Aside from these ulcerations, which were localized over an area about one inch in diameter, there were no changes either in the mucosa or in the submucosa. The picture was definitely not one of regional ileitis. As stated before, this is the only case in the series in which suppuration and fecal fistulas from appendicitis simulated regional ileitis.

As will be seen, fistulas due to regional ileitis usually behave in a manner different from those due to acute appendicitis. They do not al-

ways develop in the immediate postoperative phase. They may appear following the drainage of a residual abscess, which in turn may have developed months or even years following the initial operative procedure. Although temporary spontaneous closure may occur, recurrences are almost certain. Definite mechanical factors interfering with closure are usually absent.

CLINICAL FEATURES AND PATHOLOGY

The symptoms of the underlying ileitis which lead to the initial laparotomy may be either acute and predominantly peritoneal or chronic and mainly enteric. In the chronic cases changes in the ileum may or may not be noted, depending on the experience of the operator, the thoroughness of exploration, and the degree of involvement. Formerly, the appendix as a rule was removed, and, when noted, the condition in



Fig. 1.—Appearance of the abdominal wall of a patient who had been subjected to multiple unsuccessful local operations for fecal fistulas due to regional ileitis. There was a severe dermatitis due to the irritating intestinal and purulent discharge.

the terminal ileum was usually regarded as tuberculosis. External fecal fistulas develop only in a small proportion of such cases, and then, as a rule, not immediately after operation. In a certain number, however, progression of the disease with penetration and perforation of formerly superficial ulcers at some subsequent period will give rise to intra-abdominal abscesses. Four of the 14 cases in this series ran such a course. Intra-abdominal abscesses developed at periods of four, twelve, and eighteen months, and in 1 case seven years after the initial laparotomy. Development of fecal fistulas followed immediately upon the incision and drainage of these collections.

When the original laparotomy is undertaken for acute peritoneal symptoms, differentiation from appendicitis presents great difficulty clinically and at times at operation. Acute peritoneal symptoms in regional ileitis may occur during two different phases of the disease, the underlying pathology being different in each. In one of these there is a diffuse acute inflammatory process, limited to the terminal ileum, without actual suppuration. This is usually easily recognized operatively by the thickened, edematous, blotchy ileum. In this particular phase we know from experience that resolution will occur in a consider-

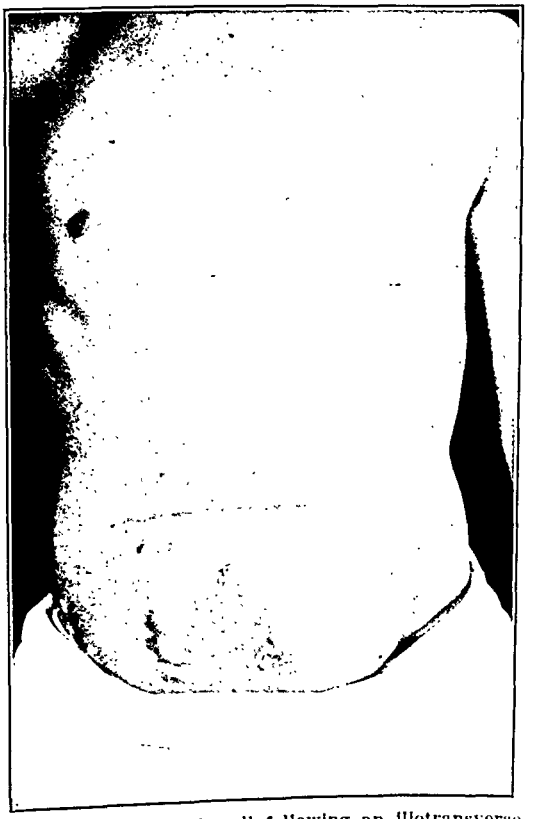


Fig. 2.—Appearance of abdominal wall following an ileotransverse colostomy with exclusion. The condition of the skin of the lower abdomen necessitated the employment of a transverse incision above the umbilicus. At present there is only an occasional watery mucoid discharge.

able number of cases. In this group development of fistulas in the immediate postoperative phase is also uncommon. Three of the 14 cases in this series were previously operated upon, as far as can be deduced from the study of the primary operative findings, during this acute stage of ileitis. One patient developed an intra-abdominal abscess followed by fecal fistulas seven weeks later. Another developed an abscess eight months postoperatively which healed for a space of two years, only to be followed by recurrence of the abscess with subsequent fistula at that

time. In the third patient an abscess and fecal fistula developed eight years following the original laparotomy.

In the other phase of regional ileitis, where peritoneal symptoms develop, the underlying cause is perforation of an ulcer in a more or less chronically diseased bowel with the production of an abscess. Seven, or one-half of the cases in this series, were subjected to primary operation at this stage of the disease. Peculiarly enough, the intestinal complaints in this group, while they could be elicited by careful questioning, were not very prominent in the patient's mind. The peritoneal symptoms which finally led the patient to seek aid were also not very severe, and

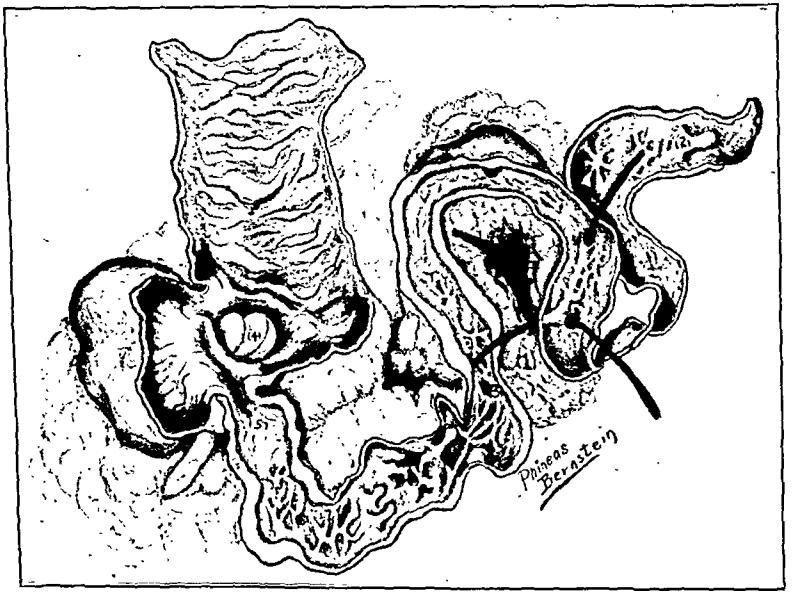


Fig. 3.—Drawing of a specimen secured at autopsy in a case dying of regional ileitis with abscess formation and peritonitis (*from* Arnheim[6]). The probes lead from ulcerations on the mesenteric border of the bowel into an abscess between the leaves of the mesentery. This abscess in turn communicated with an intraperitoneal abscess. The pathogenesis of fecal fistulas due to regional ileitis is clearly shown in this drawing. The communications with the bowel and the peri-intestinal abscesses are already present. It needed only the insertion of a drain to produce an external fecal fistula.

usually were of two to four weeks' duration. It was not uncommon for the patient to remain ambulatory for a number of weeks with these relatively mild symptoms and then to require hospitalization for sudden exacerbation of the symptoms. In all of these cases fecal fistulas developed immediately after operation. Summarizing the above experiences, it may be said that fecal fistulas due to regional ileitis do not always develop immediately after operation. They may appear following drainage of a residual abscess, which in turn may develop months or years after the primary operation. Drainage of abscesses in these cases almost invariably leads to persistent fistula formation. In 2 cases, however, temporary healing of abscesses occurred; once for four months, and once for two years.

Typical fistulas which develop in regional ileitis are indirect, tortuous, often multiple. Their internal openings are small and are frequently situated on the mesenteric side of the bowel, due to the frequency of ulceration at that portion of bowel. Perforation of such ulcers results in inflammatory processes between the leaves of the mesentery (Fig. 3). This is an important and distinctive feature of regional ileitis. Its importance may be gauged by the fact that in 10 of these 14 cases there was definite evidence of an extension along this route. In 4 of these instances fistulous tracts were found to enter the bowel on its mesenteric

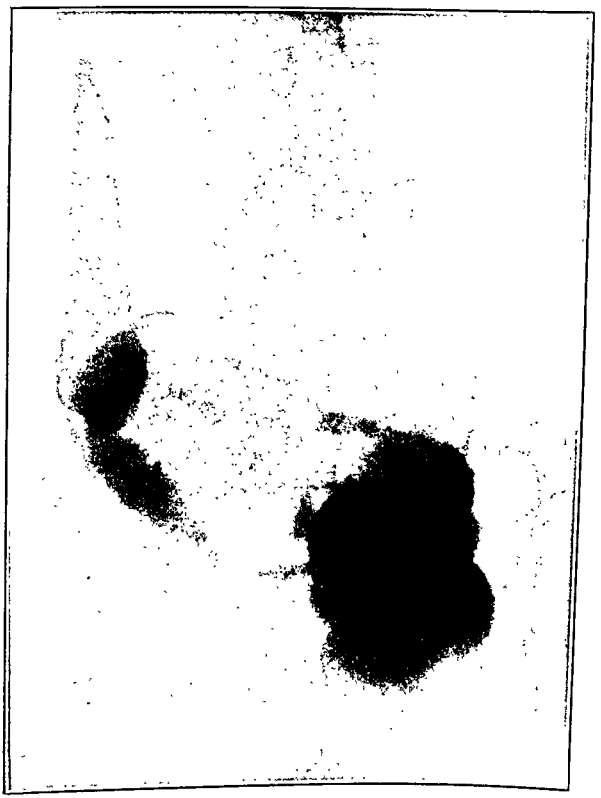


Fig. 4.—Radiograph of an ileosigmoidal fistula complicating an external fecal fistula in regional ileitis. Following the introduction of barium into the rectum, there was a rapid flow into small intestinal loops.

side. In 4 other cases localized intramesenteric abscesses were noted at some time during the course of the disease. In 2 cases widespread extension in the cellular tissue of the mesentery extended retroperitoneally to produce extensive and fatal retroperitoneal phlegmons. The coincidence of intramesenteric or diffuse or localized retroperitoneal suppuration in connection with external fecal fistulas should always serve to call the attention of the operator to the possibility of regional enteritis as an underlying cause.

Complicating ileocolic fistulas occurred 4 times, once with the transverse colon, and on 3 occasions with the sigmoid (Fig. 4). They resulted from the adhesion of one of these movable segments of colon either to diseased bowel or to an area of mesenteric suppuration. In the former instances there was a direct communication, almost like a stoma. In the cases where the mesentery of the small bowel was adherent to the sigmoid, the nature of the type of adhesion was frequently not clear in the beginning. The presence of dense adhesions, with induration between colon and terminal ileum or its mesentery, should always be suspected as evidence of fistulous communication and appropriate precautions taken when they are separated. Secondary communications with the cecum occurred six times in this series. In a number of instances communication was along the mesenteric side of the cecum apparently due to burrowing of pus between the leaves of the mesentery of the terminal ileum. Another type of fistula seemed to be due to secondary involvement of the cecum from repeated operative manipulations, chronic pericecal suppuration, and prolonged drainage. Akin to this group were those cases where coincident appendectomy accompanied the drainage of an abscess due to ileitis. Here, again, the chronic regional suppuration probably acted to prevent proper healing of the appendix stump with secondary dehiscence and fistula formation. The ileal fistulas in all instances but one originated in the terminal two feet of ileum. The bowel in all instances in which it was examined or resected except one was found to be greatly thickened, hard, hoselike in character. The changes in the mesentery have been referred to. The internal aspect of the bowel and the microscopic picture were typical of an ulcerating hypertrophic enteritis. The discharge from the fistulas was usually purulent and contained granules. The absence of grossly fecal discharge would be expected from the small size of the inner openings and the length and tortuosity of the tract. Eversion of mucosa at the internal opening is ordinarily absent. Where exploration with fruitless attempt at local repair had been made, resultant necrosis of part of the sutured bowel wall at times produced a discharge more copious and intestinal in character. Most of these patients ran a febrile course which was usually low grade. Bouts of high temperature were not uncommon, probably as a result of temporary blockage of fistulous tracts. Recurrent attacks of abdominal colic, vomiting, diarrhea, or obstipation frequently gave evidence that the underlying enteritis was still active. As a result of this combination of intraabdominal suppuration and persistent enteritis, most of these patientss had lost considerable weight and strength, were anemic and in poor general condition. In a few, however, nutrition was fairly well maintained.

In the preoperative investigation, the following studies were performed:

1. *Administration of Insoluble Carmine by Mouth.*—In cases where the discharge from the fistulas was mainly purulent this test was often decisive in establishing the presence of intestinal communications. It was positive in 12 of 14 cases.

2. *Injection of Lipiodol Through the Sinus.*—This was performed in 12 instances. In 5, communications with the ileum were easily demonstrated. In 3, no radiologic evidence of communication with the bowel could be obtained. (The carmine test was, however, positive in these 3.) In 3 instances, only communication with the cecum could be visualized, although at operation ileal openings were also encountered. These findings deserve comment. It is obvious that failure to define a communication with the ileum is no proof that such a communication is absent. Because of the narrowness and tortuosity of these tracts, it is very likely that insufficient pressure is obtained by injection to force the contrast medium into the bowel. This is especially apt to be the case if the tract enters the bowel via a peri-intestinal abscess cavity. In our experience concomitant cecal fistulas frequently have larger internal openings than the ileal fistulas, and thus permit the entrance of the injected lipiodol, which continues to pass along the line of least resistance. In a number of cases the surgeon apparently was convinced by the x-ray picture that the main lesion was in the cecum and the operation was restricted to closure of the cecal fistula.

3. *Gastrointestinal and Colonic Studies With Barium.*—These have not been of much assistance in localizing the external fistulas. In a number of cases, however, radiologic evidence of regional ileitis was obtained. Irregularities and spasm of the sigmoid may be revealed, always suggestive of fistula formation. In 1 case the presence of such an ileosigmoid fistula was actually demonstrated.

4. *Removal of Specimens From the Sinus Tracts and Walls of Abscess Cavity for Pathologic Study.*—These have usually been of negative value except in cases of actinomycosis.

Incidentally, the differentiation from abdominal actinomycosis may be extremely difficult. The question has risen 3 times in the past year. In 2 instances in which the preponderance of evidence seemed to favor the diagnosis of regional ileitis, the diagnosis of actinomycosis was finally established by biopsy. Actinomycosis was strongly suspected in the third case, but post mortem revealed regional ileitis. In regional ileitis, burrowing in the abdominal parietes is not as extensive as in actinomycosis. Retroperitoneal burrowing and extension, however, may occur in both. Large, indurated, boardlike masses, and thick dense sinus walls are not as common in regional ileitis as they are in actinomycosis. Demonstrable communication with the bowel seemed to be more common in regional ileitis. Subhepatic or subphrenic extensions have not been encountered in regional ileitis but are common in actinomycosis.

In our experience the issue can in some instances be definitely settled only by demonstration of the ray fungus.

As far as the supposedly tuberculous nature of many of these fistulas is concerned, we feel that it would be superfluous to discuss at length the reasons for the long-continued confusion of all types of nonspecific granulomas of the bowel with hypertrophic tuberculosis. This point has been very thoroughly discussed in the literature both in this country and abroad.[3-5] Suffice it to say that in none of the specimens resected in this series was there any evidence of tuberculosis.

TREATMENT AND PROGNOSIS

The primary point to be considered in the treatment of these intractable fecal fistulas is that they are but an incidental complication of a chronic ulcerative enteritis. Bearing this in mind, the futility of attempts to achieve cure by plastic closure of intestinal openings or by ileostomy becomes apparent. Not only may sutures fail to hold in the chronically thickened and inflamed bowel, but partial necrosis of the sutured portion may occur with enlargement of the internal orifices and a greater fecal discharge. The performance of an ileostomy proximally to protect such a suture line also has its disadvantages. During the period in which the ileostomy functions, the diversion probably facilitates healing of the diseased segment. A relative stenosis, however, may develop at that point, a factor which will prevent closure of the proximal ileostomy tract when the tube is later withdrawn. A new and profusely discharging fistula may develop at this point, as occurred in two of our cases.

Drainage of recurrent abscesses is of course necessary. Provision of adequate drainage will not, however, by itself insure closure of the fistula. When retroperitoneal suppuration is present, the most extensive drainage will not prevent further spread of the phlegmonous inflammation, constantly fed by intestinal extravasation. Nine of the 14 cases in this series were unsuccessfully treated by repeated drainage and local repair, 2 at this institution and 7 elsewhere. Conditions appeared only to be aggravated by these attempts, the formation of new fistulas, intestinal obstruction and adhesions, and persistent suppuration and intestinal symptoms rendering the patient more miserable and the final operation more difficult.

To achieve healing of the fistulas and to stop the further course of the disease, it is necessary to perform either enterocolostomy with exclusion, or resection of the diseased area. As a general principle, when performing a short-circuiting operation, it is the custom in this institution to practice division of the ileum proximal to the lesion. This prevents the passage into the diseased area of intestinal contents, some of which will otherwise pass by the enterocolic stoma. When this happens, the diseased segment is not put completely at rest and there is

still a tendency for intestinal contents to find their way through the fistulous opening. Furthermore, it is not uncommon for a trap to form between the diseased segment and the enterocolic stoma which, with increasing distention, may produce a new train of symptoms. For these reasons we feel that an enterocolostomy for fistulas due to regional ileitis should always be accompanied by complete exclusion. Reported failures of fistulas to heal following enterocolostomy are in a certain number of instances probably due to failure to observe this principle.

Six cases in this series were treated by ileocolostomy with exclusion. Complete healing of the fistulas and marked general improvement took place in 4 of these. In 1 case there was marked general improvement and practically complete healing of the fistula. This patient, however, continued to have recurrences of attacks of abdominal pain and fever, followed by a discharge of mucus and pus. This failure was finally demonstrated to be due to a closed loop mechanism between an area of perforation and stenosis just proximal to the ileocecal junction and the closed end of the bowel about three inches away. In the other case there was a concomitant ileosigmoidal fistula. There was marked diminution but not complete stoppage of drainage and with only slight general improvement. Fecal drainage through the excluded portion was shown to be due to retrograde passage via an excluded ileosigmoidal fistula. This patient later died following a complicated secondary resection.

Seven cases were subjected to resection (including 2 of the above ileocolostomies). There was 1 death, the one mentioned above. In all these cases the fistulas healed.

It is our custom to approach cases for ileocolostomy with exclusion through a left-sided incision as the usual site of fistulas due to operations for suspected appendicitis is on the right side. If resection is proposed, the approach is through the right side, unless the condition of the skin prohibits such an incision. In a recent case the condition of the entire lower abdomen was such that an approach below the umbilicus was impossible (Figs. 1 and 2). A transverse incision above the umbilicus was finally resorted to, and offered adequate exposure for the enterocolostomy with exclusion, which was performed. In some instances, in order to preclude the possibility of division and anastomosis at too high a level in the small bowel, we have traced the small bowel down from the duodenojejunal flexure. For the actual anastomosis we have usually preferred a side-to-side ileotransverse colostomy with closure of both ends of the divided ileum. When resection is performed, it is carried distally to include the cecum. Resection of the entire ascending colon is not as a rule necessary. Because of the lack of peritoneum on the posterior aspect of the ascending colon, we have usually drained

the colonic suture line. With resection we prefer also to place the ileocolostomy in the transverse colon. In spite of the formidable technical difficulties encountered at times, the mortality in resection is low, perhaps due to the peritoneal immunity acquired as a result of the long-standing inflammatory process. However, in a large series of cases we feel that an occasional mortality will probably be avoided if a simple enterocolostomy with exclusion is performed. The conservative attitude would appear to be the performance of such an ileocolostomy with exclusion as a first stage. Viewing subsequent conditions with an open mind, the necessity for further operation would be determined by the effect of the initial procedure on the subsequent progress of the disease.

Recurrence of ileitis proximal to the level of the ileocolostomy subsequent either to exclusion or resection is of great importance. Such recurrence or persistence of the disease was encountered twice, once after exclusion and once after resection. These cases stress the necessity of constantly bearing in mind the possibility of so-called "skip areas"; i.e., normal segments of bowel between two diseased areas. This area of normal bowel may be a number of feet in length. Furthermore, in order to be safe, division of the ileum should be performed at least one foot proximal to the site of grossly discernible disease. These two factors will probably diminish, but not entirely prevent, the possibility of proximal recurrence at a later date. This element in prognosis is really part of the question of recurrence in regional ileitis in general, a problem which is proving increasingly vexing. Of these 2 cases, the one which recurred after enterocolostomy with exclusion has been well for eight years, following secondary resection. The patient in whom recurrence took place after primary resection has remained well for three years following a secondary exclusion operation. One patient in whom resection was performed recovered from her ileitis, was well for a number of years, then developed a diffuse ulcerative colitis.

To sum up, the course of the 14 cases with fecal fistulas due to regional ileitis was as follows: Two died from extensive retroperitoneal suppuration. One of these occurred before the nature of the disease was understood, and the other patient was too sick to permit of any short-circuiting procedure. Another died from an intestinal leak and exhaustion following a complicated resection. There were no deaths following enterocolostomy with exclusion. Of the 11 patients who are alive, 10 are well (2 after secondary resection for proximal recurrences) and 1 is suffering from diffuse ulcerative colitis.

SUMMARY AND CONCLUSION

1. A study of chronic fecal fistulas at the Mount Sinai Hospital revealed that regional ileitis is a common cause of this condition.

2. The reasons for the confusion of fistulas due to regional ileitis with those due to appendicitis are reviewed and the clinical and pathologic differences between them are noted.

3. The clinical and pathologic course of that type of ileitis manifesting itself by intra-abdominal suppuration and external fistula formation is described in further detail.

4. Fecal fistulas in cases of regional ileitis with suppuration do not originate primarily in an appendix stump, but in the ulcerative lesions present in the bowel. Secondary fistulas, however, may originate at the site of the appendix stump.

5. The limitations and advantages of various methods of treatment are discussed.

The author wishes to express thanks to Drs. A. A. Berg, Ralph Colp, John Garlock, Richard Lewisohn, and Harold Neuhof for permission to study the cases admitted to their respective services.

The author also wishes to thank Dr. J. H. Globus for permission to reproduce Fig. 3.

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CONGENITAL ANOMALIES OF THE ANUS AND RECTUM

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CONGENITAL malformations of the anus and rectum may constitute an immediate danger to the life of the patient. They may cause no impairment of general health, or they may become a source of complications in later life. Their management is not difficult if based on a clear understanding of the embryology and anatomy of the various forms.

These deformities occur about once in every 10,000 births, according to Allen,[1] David,[2] Gant,[3] and others. Among the 150,354 patients admitted to the University of Iowa Hospitals during the past twelve years, there have been 28 cases of anorectal anomalies, or approximately 1 in 5,300 admissions.

Imperforate anus was recognized by Paulus, of Aegina, who in the seventh century described an operation for its relief. He passed a bistoury through the perineum and later dilated the opening with bougies. In 1640, Scultet reported a case of congenital anal stenosis successfully dilated with gentian roots. Saviard, in 1693, recorded the case of a patient with a bulging membranous closure of the rectum that he treated with a bistoury and subsequent dilatation. This method was practiced with little variation until Amussat,[4] in 1835, recommended proctoplasty by dissection and mobilization of the rectal pouch to the proper site. In 1844 French surgeons advised inguinal colostomy when perineal exploration failed. The first successful operation for imperforate anus in the United States was performed by Campbell in 1790. Bodenhamer,[5] in 1860, published an exhaustive treatise on anorectal anomalies and presented 287 cases. In 1887, Cripps[6] reported 100 operated cases with a mortality rate of 50 per cent. By 1915 the mortality had been reduced to 25 per cent in Brenner's[7] series and there has been no appreciable change since.

A review of the normal embryological development of the region is necessary if we are to understand the pathogenesis of these anomalies. Most of them are due to arrests or abnormalities of development arising in the seventh or eighth week of embryonic life. In the embryo of six weeks the cloaca is divided longitudinally by a downgrowth of the urorectal septum, but for a time there is a small opening between the urogenital tract and the hind-gut, which is known as the cloacal duct. The failure of the cloacal duct to close accounts for the anomalous connections between the urinary tract and rectum. The Müllerian ducts, as they migrate caudad at the expense of the posterior wall of

Received for publication, October 7, 1939.

the urogenital sinus, may incorporate the cloacal duct. This explains the formation of communications between the rectum and the genital tract in the female.

The rectum is separated from the external surface in early embryonic life by the anal membrane. During the seventh week a small depression, the proctodeum, appears and pushes upward until it joins the rectum by rupture of the anal membrane. Congenital anal stenosis results from incomplete rupture of the membrane. Persistence of the membrane produces an imperforate anus.

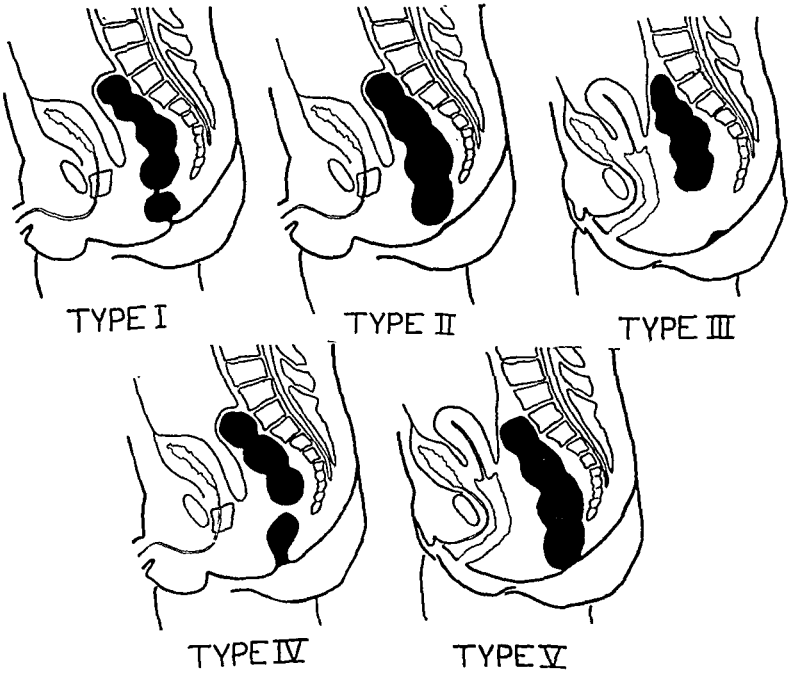


Fig. 1.—Types of anorectal malformations.
Type I, incomplete rupture of the anal membrane or stenosis at a point 1 to 4 cm. above the anus; *Type II*, membranous imperforate anus; *Type III*, imperforate anus with rectal pouch separate from it; *Type IV*, normal anus and anal pouch, rectal pouch ending blindly; *Type V*, partial or complete absence of the anal sphincter.

Anomalies in which the rectum ends blindly at a considerable distance above the perineum are due to excessive degeneration of the tail-gut. This produces a deficiency in the lower posterior portion of the cloaca. As a result the rectal pouch is left isolated from the external surface when division of the cloaca occurs. Since the external anal sphincter muscle develops from regional mesenchymal tissue, and is not dependent on the presence of the hind-gut, it is relatively normal in most types of anorectal malformations.

Congenital anomalies of the anus and rectum may be classified in several ways. The classification offered by Wood-Jones[8] is on an

embryological basis, while that of Fraser[9] and that of Drueck[10] are according to anatomical variations. Our classification is similar to the grouping of Ladd and Gross.[11] The various types of anomalies are illustrated in Fig. 1.

Fistulas between the rectum and the genitourinary system or perineum occur in combination with the above types. In the male the fistulas may be rectovesical, rectourethral, or rectoperineal. In the female the fistulas usually communicate with the genital tract. Fig. 2 shows the common forms of fistulous communications.

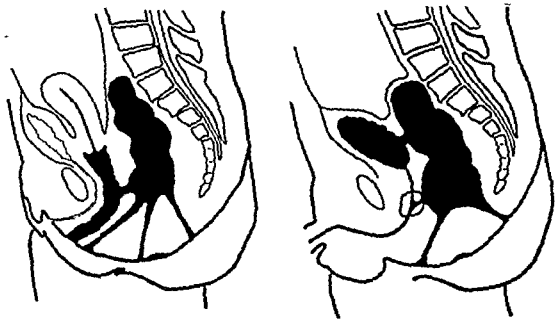


Fig. 2.—Left, common types of congenital fistulas occurring in females; right, fistulas in males.

The symptoms of anorectal malformations are varied. Chronic constipation is produced by congenital anal stenosis. This condition is thought by some to occur much more frequently than the other anomalies. Webb[12] noted four cases of anal stenosis in 150 consecutive deliveries. The passage of formed stools may dilate many of these membranous stenoses. The infant with complete occlusion of the anus or rectum usually takes feedings until the second day when symptoms and signs of intestinal obstruction appear, accompanied by dehydration. The absence of bowel movements may direct the parent's attention to the condition. If a small fistula is present, symptoms of a partial intestinal obstruction occur, and meconium is discharged from an abnormal location. Fistulas between the rectum and urinary tract are usually discovered because of the passage of meconium or gas in the urine. In these patients ascending urinary tract infection, with associated symptoms, is almost inevitable.

Careful examination will reveal the type of anomaly present. The dark discoloration of the membranous imperforate anus is due to underlying meconium. A small dimple is often observed at the normal anal site. Puckering of the skin, due to contraction of the anal sphincter, may be demonstrated by local stimulation. In the presence of a normal anus, digital examination may reveal an occlusion of the rectum. Inspection of the fundus of the anal pouch may be accomplished through an ear speculum.

Roentgenographic examination is an important diagnostic procedure. Wangensteen and Rice[13] recommended visualization of the rectal pouch in the roentgenogram by allowing gas to outline the lower bowel. This is best accomplished by holding the child in the inverted position. Any gas which is present in the colon may be forced into the rectum by gentle massage of the abdomen. This procedure is impractical during the first twenty-four hours of life, since gas does not form until the second day.

Fistulous tracts may be injected with a radiopaque substance and roentgenograms taken to show the termination of the large bowel. In patients who have had a colostomy, the distal loop may be visualized by the same method to demonstrate fistulous communications and the position of the rectal pouch.

The treatment of some anorectal malformations is simple. Repeated digital dilatation of the anal or rectal stenoses is usually sufficient to restore normal function, but occasional cases with partial membranous occlusion are best treated by incision or excision of the diaphragm-like structure. Membranous imperforate anus is easily treated by simple cruciate incision followed by occasional dilation.

There are definite indications for primary colostomy and for proctoplasty in the treatment of the more complex types of deformities. The majority of writers since the publications of Amussat[4] favor proctoplasty in all cases. This is the ideal operation because it immediately creates an anal opening in the normal location. When definite bulging of the rectal pouch in the perineum is found, proctoplasty is indicated, even when symptoms of intestinal obstruction are present. The procedure may be technically difficult in the newborn and the poor condition of many of these patients often contraindicates long difficult operations. Colostomy is the treatment of choice when the infant is dehydrated, distended, and tympanitic, and when there is no evidence of perineal proximity of the rectal pouch.

The proctoplasty is performed by making a longitudinal incision from the anterior portion of the perineum to the tip of the coccyx, dividing the anal sphincter into two lateral halves. A sound is placed in the vagina or male urethra to prevent injury to these structures. Dissection is carried upward through the levator ani, staying close to the sacrum. The rectal pouch is identified and freed from surrounding structures, care being taken not to damage the superior hemorrhoidal vessels. If the segment is short, it is necessary to carry the dissection up to the peritoneum before satisfactory mobilization of the rectal pouch to the perineum can be accomplished. Occasionally it is necessary to open the peritoneum when the bowel terminates at the pelvic floor. After suturing the levator ani and anal sphincter anteriorly, the bowel is opened and loosely sutured to the skin. Reconstruction of the posterior portion of the pelvic floor and sphincter is then completed.

Anorectal malformations associated with rectovaginal, rectovulval, or rectoperineal fistulas usually do not require immediate colostomy or proctoplasty. The fistulous openings are often of sufficient size to allow emptying of the bowel. A channel of inadequate size may be dilated to serve as an outlet for bowel contents, allowing postponement of the proctoplasty until the anatomic structures are more completely developed and easier to deal with.

The operative technique used in the treatment of rectovaginal or rectoperineal fistulas is dependent on the size of the fistulous opening. A small fistulous tract is excised, the openings closed, and the rectal pouch transplanted to the anal region. The fistulous tract large enough to allow adequate passage of feces is mobilized to the normal anal site. Following this, reconstruction of the perineum and anal sphincter is carried out.

Communications between the rectum and urinary tract are the most difficult to treat successfully. If an opening into the urethra is present, it should be closed and a proctoplasty performed. In patients with rectovesical fistulas, early colostomy is necessary. No attempt should be made to close the fistula or establish a normal anus until the pelvic structures are well developed.

In our series, 16 patients were males and 12 were females. Associated fistulas were present in 17 instances. Table I shows the distribution of the various types according to their sex and the presence or absence of fistulas. It is evident in the table that Type III is the most common anomaly and is most frequently associated with fistulas.

TABLE I

DISTRIBUTION OF THE FIVE TYPES OF ANOMALIES IN REGARD TO SEX AND PRESENCE OR ABSENCE OF FISTULAS

TYPE OF ANOMALY	MALE	FEMALE	FISTULA	NO FISTULA
Type I	2	1	0	3
Type II	5	1	2	4
Type III	8	8	13	3
Type IV	1	0	1	0
Type V	0	2	1	1
Totals	16	12	17	11

The types of fistulous communications are summarized in Table II. The significant feature of this table is the absence of instances of connections between the rectum and the urinary tract in females.

TABLE II

TYPES OF FISTULAS IN MALES AND FEMALES

TYPE	NO. OF CASES AND SEX	
Rectovesical	3	Male
Rectourethral	1	
Rectoperineal	3	
Rectovulval	4	Female
Rectovaginal	6	

Associated congenital malformations were found in 13 cases, or 46 per cent. These conditions may constitute the major problem in care of the patient. Eighteen different types of anomalies were noted, the most frequent being congenital clubfoot and deformities of the hand.

Our methods of treatment of each type of malformation with the corresponding results are given in Table III. Only patients in whom normal function of the anus and rectum has been restored are classified as "cured." All of the patients in the "improved" group have been relieved of their intestinal obstruction but continue to have some type of anal or rectal dysfunction. Stricture of varying degree is present in 6 patients. The same number complain of unsatisfactory control of the sphincter.

TABLE III

SUMMARY OF METHODS OF TREATMENT WITH RESULTS

TYPES AND TREATMENT	CURED	IMPROVED	UNIMPROVED	UNKNOWN
Type I				
Repeated dilatations		1	1	1
Type II				
Incision alone			1*	
Incision followed by dilatation	1	3		
Unsuccessful incision followed by colostomy		1		
Type III				
Proctoplasty	3	3	1*	
Unsuccessful proctoplasty followed by colostomy		3	2*	
Primary colostomy		1		
Medical treatment			2	
No treatment			1	
Type IV				
Proctoplasty followed by dilatations		1		
Type V				
No surgical treatment			2	
Totals	4	13	10	1

*Operative deaths.

The tracts have been successfully closed in 5 of the 17 patients with associated rectal fistulas. Healing occurred in 2 of 3 patients on whom operative closure of the fistulous tract was performed. Spontaneous closure of a rectovesical fistula took place following a colostomy. Proctoplasties alone closed a rectoperineal and a rectourethral fistula. Two rectovulval fistulas without obstruction or incontinence were not disturbed. Operative repair has been postponed, because of age, in 2 patients with rectovaginal communications. In the remaining 8 patients the fistulas have persisted following proctoplasty or colostomy.

Twenty-three cases were treated surgically with 4 operative fatalities, a surgical mortality of 17 per cent. Two patients have subsequently

TABLE IV

SUMMARY OF RESULTS OF SURGICAL TREATMENT (23 CASES)

TYPE	RECOVERED			DIED POST-OPERATIVELY	RESULT UNKNOWN
	GOOD	FAIR	POOR		
I		1	1		1
II	2	2	1	1	
III	3	6	1	3	
IV	1				
Totals	6	9	3	4	1
	15 (65.2%) satisfactory		7 (30.4%) unsatisfactory		

died, one of congenital heart disease and the other of intestinal obstruction due to dietary indiscretion. The result of 1 case is unknown.

The follow-up study of the results of surgical treatment is summarized in Table IV. Combining the "good" and "fair" results, 65.2 per cent were satisfactorily treated.

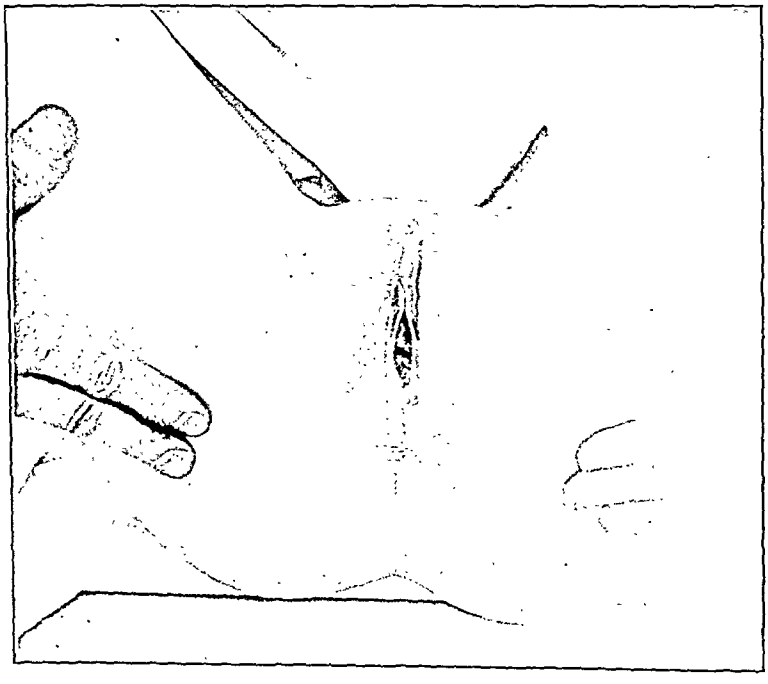


FIG. 3.—Photograph of the patient before operation. Note absence of anus with small dimple in the anal region.

CASE REPORT

A typical case of Type III anomaly and associated rectovaginal fistula is presented.

D. F., No. B-8005, a white female patient, aged 13 years, was admitted to the hospital complaining of difficulty in controlling the bowels. All of her life she had been troubled by partial fecal incontinence when the stools were liquid.

The physical examination revealed a poorly developed right thumb and wrist. There was no anal opening, but a small dimple was noted in this area (Fig. 3). Contraction of the anal sphincter could not be demonstrated. Vaginal examination revealed a rectal fistulous opening, 2.5 cm. in diameter, situated posteriorly and just above the fourchette. The vagina and lower bowel were filled with feces. After thorough cleansing with enemas and douches, the rectum was filled with barium and roentgenographic studies were made. The large dilated rectal ampulla ended 3 cm. above the perineum (Fig. 4).



Fig. 4.—Roentgenogram showing the dilated, barium-filled rectal pouch 3 cm. above the perineum.

Preoperatively, the patient was given a low residue diet, daily enemas and antiseptic douches. Sixteen days after admission, under ethylene anesthesia, a proctoplasty was performed. An elliptical incision around the vaginal fistulous opening was made and the rectal wall freed for a distance of 6 cm. The skin was incised from the fourchette posteriorly to the coccygeal region with an elliptical piece of skin excised at the normal anal site. A hemostat was inserted through

the muscle fibers of the anal sphincter and the freed rectum with its vaginal opening brought down through the newly formed tunnel. The rectal mucosa was then loosely sutured to the skin. The operation was completed by suturing the vaginal wall defect and closing the skin incision. The postoperative treatment consisted of a clear liquid diet and powdered opium for five days. The operative wounds healed well and the patient was discharged on the fifteenth postoperative day. She returned to the hospital for final examination seven months after the operation. Her bowels had moved daily and there was good sphincter control. Examination showed the anus and perineum to be well healed with no evidence of stricture or recurrence of the rectovaginal fistula (Fig. 5).

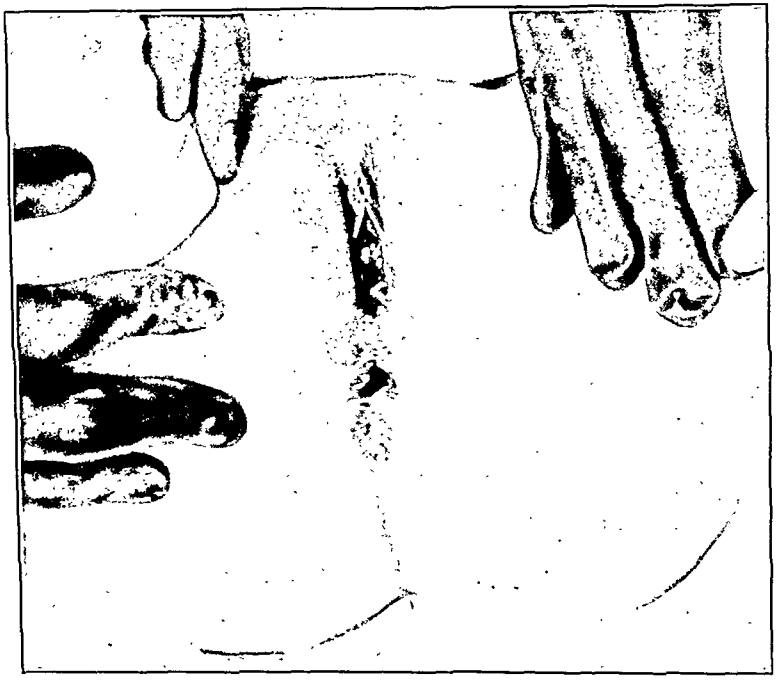


Fig. 5.—Photograph taken seven months after operation. Normal rectal function has been restored.

DISCUSSION

Anorectal anomalies are uncommon, but a surgeon may be required to care for such a patient at any time. In order to be able to manage these problems properly he must have a working knowledge of the embryology responsible for the various types of defects. All cases can be classified into five types of malformations, each requiring different methods of treatment.

Congenital malformations of this region should be suspected in infants presenting symptoms and signs of complete or partial intestinal obstruction. When an associated fistula sufficient in size to allow passage of the fecal stream is present, the true condition may not be recognized. Regional examination will make the diagnosis. Valuable information may be obtained by the use of properly taken roentgeno-

grams. These studies are of greatest value in determining the position of the blind rectal pouch. When fistulous tracts are present, their course and relationship to the bowel can be visualized with radiopaque substances.

We believe that the present high mortality in these patients can be reduced only when the surgeon realizes that the relief of the obstruction is the most important part of the treatment. In the debilitated infant with a high-lying rectal pouch the performance of a double-barreled colostomy is the safest procedure. In such circumstances the colostomy is not only lifesaving but is of value in allowing subsequent visualization of the distal, blind loop of bowel. Primary colostomy is always indicated when a rectovesical fistula is present. At a later date, when the patient's general condition is satisfactory and the anatomical structures are more fully developed, plastic procedures may be performed. It is desirable to delay complicated reconstructive procedures until the patient is 8 or 10 years of age. Even after long periods of nonuse, proper utilization of the anal sphincters usually results in satisfactory bowel control. Many fistulous tracts will close spontaneously after a satisfactory proctoplasty or colostomy. The complete relief of bowel obstruction is a prerequisite for the successful operative closure of a fistula. It must be remembered that an adequate fistulous opening without incontinence is preferable to a malfunctioning, normally located anus.

SUMMARY

1. The embryology of the anus and rectum has been briefly discussed.

2. The anomalies have been classified into five types.

3. Methods of examination including roentgenographic studies have been described.

4. Indications for proctoplasty and colostomy have been given.

5. Twenty-eight cases of congenital anorectal anomalies treated in the University of Iowa Hospitals have been reviewed.

6. A satisfactory result was obtained in 65.2 per cent of the surgically treated patients.

7. There was a surgical mortality of 17 per cent.

8. A representative case has been briefly reported.

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LYMPHOID TUMORS OF THE COLON AND RECTUM

Report of a Case of Simple Lymphoma of the Rectum

Herbert T. Hayes, M.D., and Harry B. Burr, M.D., Houston, Tex., and L. T. Pruit, M.D., Beaumont, Tex.

WHEN one begins a review of the literature on tumors of the lymphatic system, he is immediately impressed by an apparently hopeless confusion regarding nomenclature. Then there is a marked difference of opinion concerning etiology, morphology, and histogenesis. Ewing,[1] who is generally accepted as an authority on tumors, says that "the complexities of the subject of lymphoid tumors depend chiefly upon the lack of knowledge of etiology and partly upon the lack of accurate anatomical classification." He gives an excellent classification according to histogenesis and states that the three elements that may originate lymphoid tumors are: (1) lymphocytes, (2) reticulum cells of follicles and pulp, and (3) endothelial cells of pulp and cavernous sinuses.

LYMPHOSARCOMA

The most common lymphoid tumor of the large bowel is the lymphosarcoma, which is also called the small or large round-cell sarcoma. It has also been called lymphoblastoma, malignant lymphoma, lymphocytoma, granulomatous pseudoleucemia, intestinal Hodgkin's disease, and lymphoid granulation tumor. Is it no wonder that a compilation of reported cases is most difficult? A total of 371 cases of lymphoid tumors of the colon and rectum were found in the literature, of which 340 were called lymphosarcoma.[2-18] Ullman and Abeshouse have written an exhaustive study of lymphosarcoma of the intestines and find that in the colon the cecum, first, then the rectum are most frequently involved. All are agreed that metastases occur early and that the only hope of a cure is early radical removal followed by irradiation.

LYMPHOBLASTOMA

According to Martin,[19] the term lymphoblastoma is used at the Massachusetts General Hospital to include lymphogranuloma, lymphosarcoma, lymphoma, leucemia, and aleucemia. He reported nineteen cases, 5 of which involved the colon as part of a generalized intestinal involvement, while one involved the rectum alone. In this case examination showed "cartilaginous" thickenings of the rectal valves "associated with numerous ulcers which did not resemble cancer." Treatment with x-ray at four-month intervals for two and one-half years gave complete relief of symptoms.

Received for publication, September 26, 1939.

Raiford[20] reported forty-five cases of lymphoblastoma of the gastrointestinal tract seen at Johns Hopkins Hospital. Of these, one was in the sigmoid and one in the rectum. He called the latter two a "malignant reticuloma" which he defines as a "reticulum cell sarcoma" or a "malignant neoplasia of the reticulum cells of the follicles and sinuses." This may be what other authors have called a large-cell lymphosarcoma.

LYMPHOGRANULOMA

Six reported cases of lymphogranuloma (Hodgkin's disease) of the large bowel were found in the literature. Hayden and Apfelbach[21] reported four, including one of their own; Pape[23] reported one and Liebig[22] reported one. Hayden and Apfelbach say that the typical changes of lymphogranuloma are not always observed in the intestinal lesions and a diagnosis is made from the lymph glands. However, the latter may show only hyperplasia, and the typical findings are then in the bowel wall.

LYMPHANGIOMA

The recent literature contains two reports of lymphangioma of the rectum.[24, 25] It is described as a fibrous stroma containing many arterioles and dilated veins. One was a "small tumor"; the other was pedunculated.

LYMPHOMA (LYMPHADENOMA)

These terms are used interchangeably by Ewing to designate a benign lymphoid tumor. It is usually polypoid and occurs chiefly in the rectum. It is a hyperplasia of the lymphoid tissue in the submucosa that pushes before it the normal mucosa. It is thought that the term lymphoma is a better word since the word or suffix adenoma is usually applied to an epithelial tumor whose cells line glandlike depressions or cavities in the stroma.

We found twenty such reported instances;[26-35] some were called lymphoma and others lymphadenoma. They were nearly all single or multiple polypi. One patient had an annular stricture of the rectum due to infiltration of the wall by the tumor. Some were treated by resection of the rectum and others with x-ray and radium with uniformly good results. In no instance was the high frequency electric current used. Billaud and co-workers[36] reported a case which they called lymphocytoma. In this instance numerous rectal tumors occurred two years after an identical condition of the tonsils. The x-ray cured both conditions. This may well have been a simple lymphoma since the response to x-ray was so pronounced. Ewing classifies simple lymphoma as one of the clinical types of lymphoid tumors of which the lymphocytoma is the anatomical type. The other clinical types he includes in the term lymphocytoma are tuberculous lymphoma, lymphatic leucemia, pseudoleucemia, and malignant lymphocytoma.

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One month after the operation six radon seeds were implanted in the rectal wall by Dr. C. M. Griswold at the previous site of the large tumor, which latter appeared to be healing rapidly. The radon seeds were removed seven days later. Proctoscopic examination three weeks after the radon seeds were implanted showed that there was no evidence of the growth and that the site of fulguration was covered with healthy mucosa. At this time another very small polyp at the rectosigmoid was destroyed with the actual cautery.

Fluoroscopy of the colon in September, 1937, six months after the operation, confirmed the previous findings of a few polyps in the distal transverse and descending colon. Accordingly she was given five x-ray treatments in ten days by Dr. R. E. Barr, of Beaumont, Tex., during the first part of October, 1937. She was given a total dose of 1,480 r. with 200 kv., 50 cm. distance, ¾ Cu plus 2 Al, divided 720 r. anteriorly and 720 r. posteriorly. The uterus and remaining ovary were screened.

There was a marked diversity of opinion among the pathologists who studied microscopic sections of the large tumor. Dr. Martha A. Wood, of Houston, Tex., made a diagnosis of "nonmalignant chronic inflamed mucosa with lymphoid tissue beneath." Her report states: "Tissue from upper part of lesion shows much lymphoid tissue beneath the mucosa. The mucosa is ragged and degenerated. No evidence of malignant changes."

Dr. L. A. Myers, of the Memorial Hospital, Houston, Tex., made a diagnosis of "simple lymphoma, apparently of low grade chronic inflammatory origin." Following is his report: "The mass is composed of rather moderately hypertrophied lymph follicles surrounded by normal fibrous tissue with a moderate degree of inflammatory infiltration, predominantly the small round-cell type. The lymphoid follicles are made up of orderly differentiated lymph cells with practically no acute inflammatory manifestations. There is very little evidence of fibrosis. No multinuclear giant cells or Dorothy Reed cells were noted."

Dr. Violet Keiller, of the Hermann Hospital, Houston, Tex., called it a "medullary carcinoma of the rectum." She says: "Slide shows a small area of glandular epithelium. Immediately beneath this infiltrating between the muscular layers is a very cellular tumor. From the first slide examined this was thought to be lymphoblastomatous in character. More preparations were made from one of the small pieces of tissue and I believe that in these the origin from glandular epithelium can be traced. The cells of the tumor are so atypical that no glandular character is present, but I believe that the vacuolization in some areas is an indication of mucus production."

Dr. Joseph Felsen, of New York, N. Y., examined the tissue on two occasions. The first time he "felt certain the case falls within one of two groups: (1) atypical Hodgkin's disease, or (2) diffuse lymphoma of the type described by Symmers many years ago." He says in the second report that the "tissue impresses me with the possibility that this is an atypical form of Hodgkin's disease. In one section reticu-

We would like to report a case of simple lymphoma of the rectum that has a few interesting features.

CASE REPORT.—Mrs. A. C. E., aged 31 years, consulted one of us (L. T. P.) on Feb. 4, 1937, complaining of headaches, vertigo, nausea, dyspnea on mild exertion or lying flat, and pains around the heart. Family history, past history, menstrual and marital histories were irrelevant.

She had had some trouble with her heart following pneumonia; it had been said to be "weak." She had palpitation at times, as well as weakness and choking spells. On excitement or exertion there was dull pain in the left chest which radiated down the right arm, making it numb, and to a less degree down the left arm. Smothering attacks occurred at night, for which she had to sit up in order to obtain relief. There was slight edema of the ankles in the late afternoon. There was no cough, hemoptysis, or asthma.

Her appetite was good. For ten years she had had stomach trouble which had become worse the past several weeks. She had "burning" in stomach soon after eating and spit up food which set her teeth "on edge." Sometimes after eating she became nauseated and vomited food. Soreness in upper abdomen and sometimes under the right shoulder blade was present. No jaundice, cramps, diarrhea, or blood in stool was present. She has chronic constipation, for which she takes bile salts tablets.

Genitourinary-system findings were negative.

General physical examination disclosed essentially normal findings. It is interesting and essential to know that there was no lymphadenopathy.

Rectal examination showed a chronic anterior anal fissure. The anus was moderately contracted. About 8 cm. from anal margin, there was a mass on the right side of the rectum about 2.5 by 2.5 cm. which protruded 1.5 cm. into the lumen of the bowel. It was firm, not tender, and freely movable. There was a smaller polyp the size of a pea just below this growth. There were several small internal hemorrhoids.

During proctoscopic examination, the above-described tumors could be easily seen. The mucosa appeared normal. There was no ulceration or bleeding. Above the large growth, 16 cm. from the anus, there was another polypoid tumor about 0.5 cm. in diameter.

Urinalysis, blood count, gastric analysis, electrocardiogram, and basal metabolic rate were normal.

X-rays of the chest, stomach, and gall bladder disclosed normal findings.

X-ray of the colon showed: "Excess mucus in its distal half. At twenty-four hours colon is empty. Double contrast enema shows an area of the colon from splenic flexure to and including a part of sigmoid colon that is very irritable, its walls shaggy looking with patches of adherent barium scattered throughout this area. When the colon is distended with air, the patches are circumscribed and appear to be organic lesions—ulcers or polyps. Two small polyps are seen in lower part of descending colon."

The patient was advised to have the accessible growths destroyed by fulguration and x-ray treatments given the remainder of the colon.

On March 25, 1937, the small polyp at the rectosigmoid was destroyed by fulguration. This was an office procedure. She was sent to the hospital where, under a spinal anesthetic, the large growth was fulgurated the next day until it was flat with the rectal wall. Several pieces of tissue were first removed for microscopic study. At this sitting a cervical dilatation and curretage of the uterus was done by Dr. F. J. Iiams. Convalescence was uneventful and she left the hospital nine days later.

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lum cell hyperplasia is very marked. Many eosinophiles are present and some suggestive Dorothy Reed cells. The lesion appears to be in both the moderately advanced and fibrotic stages."

Dr. Fred W. Stewart, of the Memorial Hospital, New York, N. Y., says: "Were this a solitary lesion one might be inclined to regard it as a simple lymphoma. With the presence of multiple polypoid lesions shown by radiographs, I fear the process must be regarded as a part of a generalized intestinal lymphomatosis and that the disease may be expected to run a slow but eventually malignant course with extension to abdominal and other lymphoid tissues. Symptomatic x-ray treatment may control it for a considerable period."

Dr. James Ewing, of the Memorial Hospital, New York, N. Y., states: "I wish to confirm the report sent by Dr. Stewart on the lymphoid tumor of the rectum. Whether this is true tumor lymphoma or granuloma I find impossible to decide and perhaps the distinction is not important. I would certainly carry out a program of x-ray treatment and would also suggest a series of high soapsuds enemas to cleanse the colon thoroughly."

The picture as presented by the pathologists is rather confusing, but the majority have called it a lymphoma or lymphomatosis. It was practically impossible to obtain a section of the smaller lesions because, after the current was applied, there remained nothing to section. The entire disappearance of all smaller lesions after x-ray or fulguration and the excellent result obtained on the large growth by fulguration and radium is further clinical evidence that the condition is lymphoma or lymphomatosis.

It is now two years since the operation and the patient has remained in good health. Two x-ray examinations of the colon, one very recent, with double contrast enema disclosed a normal colon. Six proctoscopic examinations during this time showed a normal rectal mucosa.

SUMMARY

1. The literature on lymphoid tumors of the colon and rectum has been reviewed.

2. One case of simple lymphoma of the rectum is added to the twenty found reported in the literature.

3. Treatment consisting of local fulguration and radium together with deep x-ray over the colon has resulted in an apparent cure for over two years.

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edly on the dorsum. There is an area of cellulitis about the wound and the pus draining from it may be foul. Sometimes lymphangitis is also present. If the joint is involved, the finger is very painful on motion.

Smears of the pus may show the mixed organisms found in the mouth. The most important of these are the spirochetes and the fusiform bacilli. Streptococci and staphylococci are also commonly found but the presence of the spirochetes and fusiform bacilli usually indicates a poor prognosis. Cultures should not be regarded as negative unless anaerobic cultures have been made in addition to the routine cultures.

If the injury is seen immediately and if one is absolutely certain that the skin has not been penetrated, local cauterization with nitric acid is permissible. Dunn[16] and Lowry[17] recommend this procedure for all types of bites of the hand.

We prefer to admit the patient to the hospital, and, under general anesthesia and a tourniquet on the arm, we excise the local wound. If examination of the extensor tendon and joint capsule shows them to be intact, the wound is packed lightly and the hand and arm splinted and the patient kept in the ward. If, after forty-eight hours, no infection becomes apparent, he is discharged to a follow-up clinic.

If the tendon and joint capsule have been injured, the area should be excised and the joint capsule widely opened. Welch favors cutting the lateral ligaments and the web spaces on either side as well. It is necessary to cut the extensor tendon as it will fall back and obstruct drainage of the joint. Boric and vaseline gauzes should not be used as packs as they favor anaerobiasis.

If the patient is seen when infection is already established, that is, more than twenty-four hours after injury, we believe that the treatment should be conservative. The hand should be splinted and warm wet poultices applied. The lymphangitis and cellulitis will recede. If an abscess localizes, it should be drained. These localized abscesses may possibly be due to inoculation of the intermetacarpophalangeal bursae which lie at the metacarpal heads dorsal to the transverse capitular ligaments, between the second and fifth fingers.[18]

If the joint is involved on entry, the heads of the metacarpals soon become involved. Characteristic x-ray evidence of osteomyelitis appears and the wound continues to discharge pus. Even if the finger is saved, it will be stiff and of questionable value.

Occasionally the infection may rupture anteriorly and a tendon sheath infection result as in Welch's Case 9. If the bite has been over a terminal joint, the tendon sheath may be inoculated directly as in Case 20 of the series reported here. By way of the lumbrical canals the thenar or midpalmar spaces may be involved.

When the metacarpophalangeal joint is involved and there is osteomyelitis of the metacarpal head, amputation should be done through the metacarpal head. The cartilage should always be removed.

INFECTIONS OF THE HAND FOLLOWING HUMAN BITES

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HUMAN bites of the hand, although not a common type of injury, are frequently followed by a marked loss of function or amputation of the digit due to the complicating infection. Because early diagnosis and treatment give so much better results than delayed treatment, it seems justifiable once more to emphasize this point and to add the experience gained in the treatment of these cases at the San Francisco Hospital in the past eight years.

There are only two large series of cases described in the literature. Bates[1] states that he has had only one amputation in his last 100 cases in which he has excised the wound at once with the electrocautery. The amputation occurred in a patient who had sustained a fracture of the metacarpal as well. The other cases are not reported. Lowry[17] has had 93 bites of the fingers and hand. He treats the wound at once with fuming nitric acid and then washes the wound with water. This treatment is applied when the tendon is cut or joint capsule torn. He states that in 55 cases followed long enough to know the end results, 53 have had "good results." Case reports are not given. Welch,[2] in an excellent clinical paper, reports 18 cases in detail from the Massachusetts General Hospital. He classified his patients according to the elapsed time before entry and charted the cases reported in the literature. His classification will be used in this report. Mason and Koch[3] reported 13 cases. In addition they studied the course of infection from the dorsum of the hand by the injection mass method. Excellent drawings are given in their paper. Additional cases have been reported by Flick,[4] Bower and Lang,[5] Dimtza,[6] Frankenthal,[7] Pilot and Meyer,[8] Hudacsek,[9] Peters,[10] Fuller and Cottrell,[11] Hennessey and Fletcher,[12] and Hultgen.[13]

The clinical course, as Welch points out, is remarkably constant. The patient is usually a man who has struck another in the mouth during a fight, injuring the region over the metacarpophalangeal joint. After an interval of twelve to twenty-four hours, the hand becomes swollen and painful and the wound begins to discharge pus. Mild constitutional symptoms are present. About three or four days after the original injury, the patient appears at the hospital.

On questioning he may deny that he received a bite, but the location and the small jagged laceration, obviously made by something blunt, should make one suspicious. The hand is usually swollen, most mark-

Received for publication, September 25, 1939.

3. If the patient presents himself after infection is already established, the treatment can be more conservative.

TABLE II*

DELAYED CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Flick	3	2 (hand in one)		1
Frankenthal	1	1		
Dimtza	2		1	1
Mason	5	1	3	
Welch	10	4		
Peters	1			
Hultgen	1			
Fuller	1	1		
Smith	4			
Maier	10	4		
Cohn	18	2	2	

*After Welch's classification.

TABLE III*

LATE CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Mason	6			
Welch	5	2	1	
Pilot	1	1		
Hennessey	1	1		
Cohn	10	4	2	1

*After Welch's classification.

CASE REPORTS

I. Early Cases.—

CASE 1.—D154363, D. McS. A 48-year-old police officer received a bite over the metacarpophalangeal joint of the index finger of the left hand while making an arrest. He reported immediately. A shallow laceration not penetrating the skin was cauterized. After twenty-four hours of treatment with hot wet poultices, the patient was discharged. He returned in three days, however, with a local area of cellulitis around the skin laceration. After forty-eight hours more of poulticing and splinting, the cellulitis cleared up.

CASE 2.—D100103, P. M. A man, 30 years of age, received a bite over the metacarpophalangeal joint of the middle finger of the right hand in a street fight twelve hours before entry. There was edema of the dorsum and an area of cellulitis surrounding the laceration. An x-ray showed no fracture. On splinting and hot soaks the infection cleared up in three days.

CASE 3.—D172152, B. B. A man, 36 years of age, entered with a bite over the metacarpophalangeal joint received in a street fight twenty-four hours before entry. There was edema of the dorsum and an area of cellulitis around the laceration as well as a few streaks of lymphangitis extending up the arm. Following application of heat, the infection subsided in three days.

CASE 4.—D175775, E. H. A 25-year-old man received a bite over the metacarpophalangeal joint of the middle finger of the right hand. He reported at once to a hospital where the laceration was sutured. The next morning the area about the wound was red, swollen, and tender and the entire hand was painful. On

Postoperatively, the splinting should be continued. The dorsum should be directed downwards to promote drainage by gravity. Sterile hand soaks can be used with benefit. This should not be continued for more than a few days because of the resulting maceration and edema. The solution used is not considered of much importance. Saline solution or potassium permanganate 1/1,000 is satisfactory. Dakin's solution is somewhat painful, especially in the acute stages.

The use of arsenicals intravenously has not been demonstrated to have any effect other than to deodorize the wound when spirochetes are present. Flick and Maier both used arsenicals locally to irrigate the wound. There was no benefit noted from intravenous neoarsphenamine in the present series of cases.

Smith and Manges reported 8 cases of bites of the hand in which x-ray treatment was used with uniformly good results. They gave 50 to 100 r. measured in air of 135 kv. x-ray filtered with 4 mm. of aluminum at each dose. However, as none of their patients had bone or joint involvement, the value of the x-ray therapy has not been proved.

There are 35 cases of human bites of the hand in the records of the San Francisco Hospital for the past eight years. These have been classified, after the suggestion of Welch, into early cases (before twenty-four hours), delayed cases (twenty-four hours to seven days), and late cases (seven days and later). The only amputation in the early group was performed on a patient who had had the laceration sutured immediately. There were two amputations in the delayed group and four in the late group. One patient in the late group died of bronchopneumonia following drainage of the hand.

A summary of the cases reported in the literature divided according to the elapsed time of injury before entering the hospital is given in Tables I, II, and III.

TABLE I*

EARLY CASES

AUTHOR	NO. OF CASES	AMPUTATIONS	LOST FUNCTION	DEATHS
Flick	3	1	1	
Bower	1			
Dimtza	1	1 (arm)		
Mason	2		2	
Welch	3			
Smith	4			
Maier	7			
Cohn	7	1		

*After Welch's classification.

CONCLUSIONS

1. The cases reported re-emphasize the necessity for immediate and radical treatment of human bites of the hand.

2. The prognosis of human bite infections of the hand is determined by (a) the type of organism present, (b) the time before surgery is instituted, and (3) the involvement of the tendons and joints.

tions were seen on the dorsal surface of the finger from which pus could be expressed. Smears and cultures showed only hemolytic streptococci. The subcutaneous tissues were drained and the finger slowly improved after three weeks' hospitalization.

CASE 12.—D134466, T. D. A 75-year-old man was bitten on the dorsum of the right hand over the metacarpophalangeal joint of the middle finger two days before entry. The hand became swollen, hot, and tender and the finger was painful to motion. In spite of heat and rest, there was no improvement. Two weeks after entry the joint was found to be involved. The finger was amputated.

CASE 13.—D133371, G. E. A man, 31 years of age, received a bite on the right hand over the metacarpophalangeal joint of the middle finger four days before entry. Two days later, in spite of soaks, the hand became swollen and tender. On entry an area of cellulitis was seen about the laceration from which pus could be expressed. On heat and rest the hand rapidly improved.

CASE 14.—D160359, J. R. A 19-year-old boy received a bite over the metacarpophalangeal joint of the fifth finger of the right hand four days before entry. He tried soaks without benefit. On entry the dorsum of the hand was edematous and around the wound there was a grayish black necrotic zone. With the application of heat and splinting an abscess localized eleven days after entry. This was drained. The pus yielded a pure culture of hemolytic streptococci. The wound healed after two months, but no motion was present in the fifth metacarpophalangeal joint.

CASE 15.—D187618, G. LaR. A man, 43 years of age, received a bite over the metacarpophalangeal joint of the right index finger four days before entry. After two days the hand became painful and the finger was swollen and tender. On entry a shaggy laceration was seen. A smear showed gram-positive cocci but no spirochetes. The area was opened, but the joint was not involved. Neoarsphenamine, 0.3 gm., was given. On rest and soaks the infection rapidly subsided.

CASE 16.—D185772, J. S., a man, 36 years of age, received a bite over the first metacarpophalangeal joint of the right hand three days before entry. The day before entry the hand became painful and red streaks were seen. On entry a small dirty laceration was noted from which streaks of lymphangitis extended up the arm. Smears from the ulcer showed gram-positive cocci but no fusiform bacilli or spirochetes. On heat and rest the inflammation subsided in one week.

CASE 17.—D170986, J. V. A man, 32 years of age, received a bite on the lower third of the forearm four days before entry. On entry a dirty shallow ulcer about 2 cm. in diameter was noted on the dorsum of the forearm just above the wrist. From the ulcer there were several streaks of lymphangitis extending up the arm. The area was excised with the cautery. After two attempts a graft took and the wound healed.

CASE 18.—D157229, W. K. A man, 23 years of age, received a bite over the metacarpophalangeal joint of the fourth finger of the right hand two days before entry. He used soaks at once but the hand became more swollen and painful. On entry a ragged wound was seen surrounded by an area of cellulitis. An x-ray showed thinning of the joint cartilage. Two days after entry the wound was opened and the capsule found to be torn. It was opened widely and packed. One month after entry the hand was said to be "healing."

CASE 19.—D188783, O. B. A man, 35 years of age, received a bite over the proximal joint of the index finger of the left hand two days before entry. He received emergency treatment. The finger soon became painful to motion and swollen. On entry a small laceration was seen from which thin pus drained.

entry, the sutures were removed and the wound explored. The tendon (extensor) and joint capsule were torn and the cartilage was cracked. The wound was débrided and packed open and soaks were started. Smears from the wound showed gram-positive cocci and filamentous bacilli. No spirochetes were found. The wound continued to drain and the extensor tendon sloughed. One month after entry the finger was amputated through the metacarpal. Four months after entry the wound had healed, but the movements of the remaining fingers were considerably impaired.

CASE 5.—D189635, W. M. A man, 25 years of age, received a bite over the metacarpophalangeal joint of the ring finger of the right hand twenty-four hours before entry. The hand was swollen and the finger tender. Pus was discharging from the ragged laceration. Smears were negative. No aerobic growth was attainable, but anaerobically a gamma streptococcus and small gram-negative coccus grew. The wound was débrided. At operation a tear in the joint capsule was noted. The joint was opened widely and the wound packed. A cast was applied. In one month the wound had healed and the motions of the hand were rapidly being restored to normal.

CASE 6.—D192323, W. L. A man, 38 years of age, received a bite on the ventral surface of the distal joint of the ring finger twenty-four hours before entry. Smears from the small laceration showed no organisms. With the application of heat, the local infection subsided in three days.

CASE 7.—D196804, H. B. A 32-year-old man received a bite over the metacarpophalangeal joint of the middle finger of the right hand twelve hours previously. On entry the hand was tender to motion. Extending from the laceration were several red streaks. There were enlarged tender glands in the axilla. Smears from the wound showed diphtheroids and staphylococci. An x-ray was negative. With the application of heat, the process subsided in four days.

II. Delayed Cases.—

CASE 8.—D172233, G. T. A man, 42 years of age, received a bite on the right hand over the fourth and fifth metacarpophalangeal joints two days before entry. The wound was cauterized by his doctor at once. The next day the hand became tender and slightly swollen. On entry the local area was red and indurated and discharged pus. Smears showed gram-positive cocci in chains and bunches. With the application of heat, the infection slowly subsided during the course of one week.

CASE 9.—D151769, E. P. A man, 41 years of age, received a bite over the knuckle of the left hand two days before entry. He cauterized the wound with iodine, but the back of the hand became swollen and tender. On entry a small ragged laceration was noted surrounded by an area of cellulitis. With the application of heat and splinting, the infection subsided in three days.

CASE 10.—D98831, L. R. A man, 20 years of age, received a bite over the metacarpophalangeal joint of the right index finger three days before entry. The next day the hand began to swell and was painful to motion. On entry a small dirty wound was noted from which nonfoul pus could be expressed. A subcutaneous abscess was drained. One intravenous injection of neoarsphenamine 0.3 gm. was given. The hand rapidly improved.

CASE 11.—D152605, J. M. A 66-year-old woman was bitten on the index finger of the right hand four days before entry. The finger became swollen and drained pus in spite of constant soaking in hot water. On entry several shallow lacera-

scess was opened. There was no improvement. On entry the entire finger was brawny, swollen, stiff, and tender. Pus was discharging from a wound on the dorsum of the finger. An x-ray showed osteomyelitis in the phalanges of the finger as well as demineralization of the entire hand. Three months after the original injury the finger was amputated. The stump was slowly healing over.

CASE 27.—D176087, J. S. A man, 35 years of age, received a bite over the first metacarpophalangeal joint of the right hand ten days before entry. He reported at once to a hospital where the laceration was sutured. Three days before entry the wound broke down and discharged pus. The hand was painful and swollen. On entry there were several streaks of lymphangitis extending up the arm. An x-ray of the hand showed no osteomyelitis. Following poulticing and regression of the lymphangitis, the wound was opened and drained. The joint capsule was not damaged. Healing took place rapidly.

CASE 28.—D161898, J. R. A man, 29 years of age, received a bite on the right fifth finger while confined in jail twenty days before entry. He consulted a doctor two days later and was advised to soak the hand in hot water. The finger became more swollen and tender. On examination the original wound was noted over the distal joint. The entire finger was swollen, red, and tender. The distal joint was disarticulated. When seen two months later, the third, fourth, and fifth fingers of the right hand were stiff and there was limitation of motion at the wrist joint. Physiotherapy was instituted.

CASE 29.—D157239, F. N. A man, 36 years of age, received a bite over the metacarpophalangeal joint of the index finger of the right hand seven days before entry. The laceration was sutured at once at another hospital. The next day the hand started to swell and become painful to motion. Three days before entry the sutures were removed and the wound discharged pus. On entry the hand was swollen and the right index finger painful to motion. Foul pus was draining from the wound. Smears of the pus showed spirochetes and fusiform bacilli. The wound was opened and drained and the joint capsule found to be torn. The patient was given heat and rest as well as two intravenous injections of neoarsphenamine. A second drainage was performed without improvement. One month after entry the finger was amputated. The stump healed over in three weeks' time.

CASE 30.—D164309, H. R. A 22-year-old man received a bite on the left fifth finger seven days before entry. He was treated at once in a hospital. Two days later the wound began to drain foul pus. Then the hand became swollen. On examination a foul dirty wound was seen on the dorsum of the finger. Smears showed spirochetes and fusiform bacilli. An x-ray showed osteomyelitis of the second phalanx. He was given one injection of neoarsphenamine. Two weeks after entry the distal two phalanges were disarticulated. Healing took place slowly.

CASE 31.—D144083, O. S. A man, 45 years of age, received a bite on the left fourth finger fourteen days before entry. He neglected to treat it in any manner. On entry there was limitation of motion of the hand with a wound on the dorsum of the fourth finger from which pus could be expressed. Smears showed streptococci, staphylococci, and small bacilli. An x-ray showed osteomyelitis with destruction of the joint of the terminal phalanx. Drainage was instituted and the small bones allowed to sequestrate themselves.

CASE 32.—D188953, J. L. A man, 32 years of age, received a bite over the metacarpophalangeal joint of the fourth finger of the left hand thirty days before entry. He was treated elsewhere. After one week the inflammation seemed to subside. Seven days before entry the site of injury became swollen and tender, gradually increasing in extent. He had an old history of asthma and bronchitis.

Smears showed no organisms but both hemolytic streptococci and staphylococci were present on culture. When the wound was drained, the joint was seen to be intact. The infection rapidly cleared following drainage.

CASE 20.—D183973, L. P. A man, 48 years of age, received a bite over the distal joint of the index finger of the left hand three days before entry. The finger became swollen and painful to motion. On entry the entire finger was swollen and painful. Tenderness was present over the course of the tendon sheath. A smear from the wounds showed spirochetes, fusiform bacilli, and gram-positive cocci. Cultures showed "mouth organisms." The patient was given 0.45 gm. neoarsphenamine intravenously. The tendon sheath was opened and the tendon found to be necrotic and sloughing. Five days later the finger was disarticulated at the metacarpophalangeal joint. An x-ray taken at this time showed osteomyelitis of the head of the metacarpal. Small sequestra continued to discharge. Healing did not take place for five months.

CASE 21.—D210553, S. R., a man, 42 years of age, received a bite over the metacarpophalangeal joint of the right index finger six days before entry. Two days later the hand became swollen, tender, and painful to motion. On entry the hand was brawny, red, and indurated about the laceration. An x-ray showed no fracture. On heat and rest the inflammation rapidly subsided. During the course of treatment, sulphanilamide and x-ray therapy, 150 r. through a 25 by 15 field were also given.

CASE 22.—D191133, C. A. A 25-year-old man received a bite over the metacarpophalangeal joint of the right fifth finger three days before entry. Examination showed a diffusely swollen hand with an area of cellulitis about the laceration. There were enlarged tender glands in the axilla but no lymphangitis. An x-ray showed no fracture. The patient signed his release the next day.

CASE 23.—D194513, H. P. A man, 27 years of age, received a bite over the metacarpophalangeal joint of the thumb of the left hand five days before entry. Two days before entry the hand became swollen and painful. Examination showed a ragged laceration surrounded by an area of cellulitis. A Wassermann test was positive, but the patient had an old history of syphilis for which he had been receiving treatment. The wound was opened and the joint capsule was found to be intact. On heat and rest the infection rapidly subsided.

CASE 24.—C. A. A man, 26 years of age, received a laceration over the metacarpophalangeal joint of the right fourth finger four days before entry. The day before entry the hand became swollen and painful to motion. On entry a local area of cellulitis was seen about the laceration. On heat and rest the infection rapidly subsided.

CASE 25.—D210580, G. S. A woman, 42 years of age, received a bite on the right thumb two days before entry. The next day the thumb became swollen and painful. The pain extended up the arm to the axilla. The patient felt feverish. Examination showed a ragged laceration on the dorsum of the thumb from which pus was draining. Smears showed staphylococci and streptococci. After five days of heat and rest an abscess localized. An incision was made on the dorsum of the thumb and extended up to the wrist. The joint capsule was not involved. An x-ray of the hand was negative. When seen two months later, the tendon of the extensor pollicis longus was sloughing.

III. Late Cases.—

CASE 26.—D127434, M. M. A man, 49 years of age, received a bite over the right index finger seventy-five days before entry. He had been treated by soaks and intravenous neoarsphenamine. The finger continued to drain and a small ab-

scess was opened. There was no improvement. On entry the entire finger was brawny, swollen, stiff, and tender. Pus was discharging from a wound on the dorsum of the finger. An x-ray showed osteomyelitis in the phalanges of the finger as well as demineralization of the entire hand. Three months after the original injury the finger was amputated. The stump was slowly healing over.

CASE 27.—D176087, J. S. A man, 35 years of age, received a bite over the first metacarpophalangeal joint of the right hand ten days before entry. He reported at once to a hospital where the laceration was sutured. Three days before entry the wound broke down and discharged pus. The hand was painful and swollen. On entry there were several streaks of lymphangitis extending up the arm. An x-ray of the hand showed no osteomyelitis. Following poulticing and regression of the lymphangitis, the wound was opened and drained. The joint capsule was not damaged. Healing took place rapidly.

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CASE 32.—D188953, J. L. A man, 32 years of age, received a bite over the metacarpophalangeal joint of the fourth finger of the left hand thirty days before entry. He was treated elsewhere. After one week the inflammation seemed to subside. Seven days before entry the site of injury became swollen and tender, gradually increasing in extent. He had an old history of asthma and bronchitis.

On entry an area of cellulitis was seen about the laceration which was again discharging. An x-ray showed no osteomyelitis or fracture. With gas oxygen ether anesthesia the wound was drained. The tendon was found to be frayed, but the joint capsule was intact. Following operation the patient developed bronchopneumonia from which he died.

CASE 33.—D189719, O. St. J. A man, 29 years of age, received a bite over the index and middle fingers and the third metacarpophalangeal joint of the right hand nine days before entry. Five days before entry the skin overlying the areas became black and necrotic. Two days before entry he noted red streaks extending up the arm. Examination showed shallow superficial ulcers at the sites of injury from which a well-marked lymphangitis extended. On heat and rest the infection rapidly subsided.

CASE 34.—D141428, F. M. A man, 22 years of age, received a bite over the metacarpophalangeal joint of the right middle finger fourteen days before entry. The hand did not become painful until three days before entry. On examination a crusted superficial lesion was seen surrounded by an area of induration from which several streaks of lymphangitis extended up the arm. Smears from the lesion showed only gram-positive cocci in chains. On heat and rest a superficial abscess localized. Following drainage the infection rapidly subsided.

CASE 35.—D180760, E. B. A man, 49 years of age, received a bite over the ventral surface of the fourth finger of the right hand eight days before entry. The finger became discolored and swollen. An x-ray showed osteomyelitis and suppurative arthritis of the proximal interphalangeal joint. The wound was drained. When seen four months later, the right fourth and fifth fingers had developed a flexion contracture.

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PNEUMOCOCCIC PERITONITIS

Its Present Status

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PATHOGENESIS

THERE is much difference of opinion regarding the avenue by which the pneumococci may reach the peritoneum. Obadalek[1] believes that the bacteria are swallowed and that they migrate through the intestinal wall in the region of the ileocecal valve because of stasis in this area. He does not believe that the genital tract can be a site of invasion unless the feces contaminate the vagina. Koennecke[2] also believes that the bacteria are swallowed, but that they enter the peritoneal cavity only by contamination of the genital tract by fecal material. Jensen,[3] Wolfsohn,[4] and McCartney and Fraser[5] fed pneumococcus cultures to mice; none were able to produce peritonitis, but Jensen found bacteria in the walls of the intestines.

Rischbieth[6] advances the view that pneumococcic peritonitis is always secondary to septicemia. Blake and Cecil[7] were unable to produce pneumonia or peritonitis by intravenous injection of pneumococci; the animals died from the bacteremia. Jensen,[3] and McCartney and Fraser[5] showed that pneumococci reached the blood stream in a rabbit a few minutes after intraperitoneal injection. Rolleston[8] found eleven cases of peritonitis in 4,454 cases of pneumonia; Rischbieth[6] found one case in 6,000 cases of pneumonia; Elkin[9] reports three in 1,908 cases. Peiser[10] believes that the uninjured peritoneum is impermeable to the invasion of organisms from the blood stream.

McCartney and Fraser[5] refute the hematogenous and enterogenous avenues of infection; they believe that primary pneumococcic peritonitis occurs only in females and that the genital tract is always the portal of entry; it follows that all cases in males are of the secondary type.

DIAGNOSIS

This disease has a predilection for children up to the age of 14 years; females predominate in a ratio of about 5:1. The onset is acute; only rarely is there a prodromal period of one or two days during which the patient complains of general malaise, cough, or gastrointestinal upset. The disease usually begins suddenly with nausea, emesis, and severe abdominal pains; the temperature is high. Constipation is the exception and diarrhea the rule; the latter can be considered almost

Received for publication, September 26, 1939.

pathognomonic. There is frequency of urination. The general condition is fairly good at the onset; this is remarkable since the mortality is very high at this stage, but this can probably be explained by the absence of the facies abdominalis which one is accustomed to see in severe cases of peritonitis.

Cyanosis of the face is frequently seen and there is often herpes labialis. The pulse is usually good in the early stages of the disease. The early diagnosis of peritonitis is obvious; there is tenderness of the entire abdomen with muscular rigidity; however, the rigidity is not as pronounced as in other forms of peritonitis and may be described as having a doughy consistency. The leucocyte count is usually high, although this is not a constant finding; the count frequently reaches 30,000 to 40,000 leucocytes per cubic millimeter of blood; the polymorphonuclear leucocytes usually comprise 80 to 90 per cent of the total. A positive blood culture is obtained soon after the onset and it tends to remain positive until all exudate has been evacuated from the peritoneal cavity; the organisms in the blood stream and the peritoneal cavity are always of the same type. Pneumococci of the same type can also be recovered from the spinal fluid. Bronchitis and pneumonia are frequent early complications. The acute phase usually ends in death a few days after the onset; however, the patient may be sufficiently fortunate to enter the subacute and subsequently the chronic stages of the disease. During the subacute phase, the temperature falls and the patient appears to be better; the diarrhea and emesis cease and the abdominal tenderness diminishes. In about four days the chronic phase is reached; the temperature rises and the abdominal circumference increases; abdominal palpation discloses fluctuation and fluid wave. An abscess can be outlined; this abscess sometimes reaches considerable size and may lead to cachexia and death or may perforate through the abdominal wall, usually at the umbilicus. Metastatic abscesses may develop in bones and joints; pneumococci can be recovered from these foci.

The condition most often confused with pneumococcic peritonitis is acute suppurative appendicitis with or without perforation; the confusion is increased by the fact that the pain in the former often begins in the right lower abdominal quadrant. However, there are a few points which make the differentiation fairly simple. The leucocyte count is usually three or four times greater and the fever is earlier and higher in pneumococcic peritonitis. The pain, tenderness, and rigidity are more diffuse in pneumococcic peritonitis. Diarrhea is seen in practically every case of pneumococcic peritonitis while constipation is the rule in appendicitis. A final complete differentiation can be made by abdominal puncture with a lumbar puncture needle. Neuhof and Cohen[11] made one hundred peritoneal punctures to determine the causative organism in peritonitis; they were able to isolate

the organism in every case and in no instance was there puncture of the intestines. In most females pneumococci can be found in the cervical exudate even before the peritonitis develops.

PATHOLOGY

Pneumococcic peritonitis is commonly divided into primary and secondary types, but this is a differentiation for convenience only; the term primary means merely that the origin of the infection is not known, while in secondary cases there is a known previous focus of infection. Actually, all so-called primary cases occur in females and are secondary to pneumococcic cervicitis and endocervicitis. Michant,[12] in 1901, was the first to suggest this classification and it has since been followed without outspoken question. Many authors divide the pathology into diffuse and localized types as though they were entirely different varieties of the disease; this is incorrect because the process is always diffuse in the acute and subacute stages and always becomes localized in the chronic phase. About 40 per cent of all pneumococcic peritonitis occur as complications of nephrosis; however, pneumococci and streptococci are about equally divided in the etiology of nephrotic peritonitis. In nephrosis there is a low colloidal osmotic pressure of the blood which causes an abnormal tendency toward filtration of plasma from the blood stream into the peritoneal cavity. This ascitic fluid offers an excellent culture medium for both pneumococci and streptococci.

In the acute stage of the disease there are peritoneal hyperemia and edema with the production of a layer of fibrin over all serosal surfaces; mesenteric lymphadenitis is commonly observed. In females there are usually hyperemia and edema of the oviducts. The peritoneal cavity contains a serous exudate in the acute phase, which lasts only about seventy-two hours, at the end of which time the subacute stage is reached; this period usually lasts for about four days. During this stage the exudate becomes purulent and the peritoneum makes an attempt at localization; the exudate contains large flakes of fibrin which cause the formation of multiple adhesions and subsequently one or more abscesses. When the abscess formation or localization process becomes complete it may be said the chronic stage has been reached. These abscesses may perforate spontaneously through the abdominal wall at the umbilicus or into the rectum. The bacteria usually enter the blood stream in the acute phase and may be deposited in various parts of the body, producing pneumonia, bronchitis, pericarditis, pleuritis, arthritis, or otitis media.

TREATMENT

Here, as in many other diseases, good treatment depends upon good diagnosis. Most of the recorded deaths have occurred in cases that were erroneously diagnosed as acute surgical emergencies and oper-

pathognomonic. There is frequency of urination. The general condition is fairly good at the onset; this is remarkable since the mortality is very high at this stage, but this can probably be explained by the absence of the facies abdominalis which one is accustomed to see in severe cases of peritonitis.

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When localization is definitely complete, drainage should be obtained; if the patient is a female and fluctuation can be elicited in the posterior fornix by vaginal examination, very safe and efficient drainage may be secured by posterior colpotomy. In all other cases a small incision should be made over the site of maximum fluctuation; incision should be made under local anesthesia when possible; if inhalation anesthesia is employed, it should be a light type, preferably nitrous oxide. From one to three Penrose drains should be inserted through the incision and left in situ until a satisfactory sinus tract has been established; this may require from two to seven days.

The patient should be closely observed for several weeks after recovery appears to be complete as sequelae are often delayed and peritoneal abscesses sometimes recur after drainage has ceased.

STATISTICAL DATA

Salzer[14] reports 31 cases with a mortality rate of 40 per cent; of 8 cases operated upon during the acute stage, 6 died; he made an early diagnosis in 21 cases and treated them conservatively; 15 of these cases recovered. He emphasizes the importance of making a cervical smear to facilitate early diagnosis. Mathieu and Davioud[15] report 12 cases, all of which were females; each case had diarrhea and was preceded by sore throat. They advise expectant treatment with drainage late, if at all. McCartney and Fraser[5] report 56 cases, 44 per cent of which were females; their mortality rate was 42 per cent; in 11 of the 12 males pneumonia was the primary source of infection. In their investigation they found that the bacteria could not migrate through the intestinal wall. They feel that the bacteria enter the vagina and reach the peritoneal cavity by way of the uterus and oviducts.

Lipschutz and Lowenberg[16] report 13 cases with a mortality rate of 100 per cent; 80 per cent of their cases were operated upon; 90 per cent began with a sore throat; 12 of the 13 cases were females. They found pneumococci in 3 vaginal smears and blood cultures were positive in 9 instances. They believe that the genital tract is the portal of entry; they found a maximum amount of involvement in the right lower abdominal quadrant; therefore, they advise incision and drainage in this area.

Cole[17] reports 26 cases covering an eighteen-year period at St. Louis Children's Hospital; there were 14 deaths with a mortality rate of 54 per cent. There were 10 cases of nephrosis, of which 7 died, giving a corrected mortality rate, exclusive of this group, of 44 per cent. Contrary to the general belief that patients with pneumococcic peritonitis belong to the lower strata of society, Cole found that all of his patients had the advantage of average living conditions. Of the 16 nonnephrotics, 7 were presumably secondary to upper respiratory infections; 9 cases demonstrated no primary lesion. Five patients were

ated upon. The appallingly high mortality rate in this disease could be materially lowered by correct early diagnosis and expectant treatment until several days after the infection has become completely localized. Operation should never be performed until one or more definitely localized collections of exudate can be positively elicited. Diagnosis can be made immediately by peritoneal puncture and cervical smear. There is sufficient sound and intelligent treatment necessary during the waiting period to keep the physician occupied.

The carbon-dioxide combining power of the blood should be determined and oxygen administered if anoxemia is present. Sufficient exudate should be obtained from the cervix by applicator and from the peritoneal cavity by puncture to prepare cultures; the blood should also be cultured. The pneumococcus should be typed and sufficient antipneumococcic serum immediately administered; 20,000 units should be given intravenously every four hours during the first twenty-four hours; during the second twenty-four hours 20,000 units should be given intramuscularly every four hours. A total of 240,000 units should be given; serotherapy probably has little effect upon the actual peritonitis, but it decreases the possibility of complications, more particularly pneumonia.

Paralytic ileus may be controlled by an indwelling duodenal tube with continuous suction and by lumbar anesthesia; 250 c.c. of blood should be administered every forty-eight hours. Forty-eight gr. (3.2 gm.) of sulfanilamide in 400 c.c. of isotonic saline solution may be given every twelve hours; if given intravenously, the drug is eliminated by the kidneys before any benefit can be derived. The efficacy of sulfanilamide in pneumococcic peritonitis is still open to debate. The diarrhea can be successfully controlled by the use of any of the commercial kaolin preparations either by mouth or by retention enemas. The patient should be allowed no food or water by mouth; the fluid balance should be maintained by the use of glucose, saline, or Hartmann's solution by the intravenous route.

The treatment that definitely saved the life of the patient herein reported is that described by Crocker, Valentine, and Brody,[13] the use of controlled nonspecific immunotransfusions. A donor is given fifty million killed typhoid bacilli intravenously; if there is no reaction within one hour, twenty-five million additional bacteria are administered. A maximum reaction is reached in about eight hours, at which time the donor's temperature may be from 104° to 105° F. and his blood may contain from 25,000 to 30,000 leucocytes per cubic millimeter. At the peak of the reaction, the patient is given 250 to 300 c.c. of this blood by transfusion. After employing this treatment on a number of cases of bacteremia, I have concluded that one hundred million bacteria should be given at the first injection and that 350 to 400 c.c. of blood should be transfused.

and 4 were positive; vaginal cultures were positive in 7 cases. Only 1 patient operated upon in the acute stage recovered; all other patients operated upon in this phase died. Bass emphasizes the importance of vaginal smears and peritoneal punctures as means of making an early diagnosis; he believes that specific antiserum should be given as soon as the type of organism is determined.

Fricke[24] reports 10 cases covering a five-year period at the Lenox Hill Hospital; 8 were children and there were 2 adults. Of the 8 children, 7 were females, and both of the adults were females. Six of the children died and both of the adults recovered, giving a mortality rate of 60 per cent. Six of the children gave a past history of pertussis, an element which Fricke believes to be significant. One of the adults had postabortion peritonitis and was treated with specific serum without operation; the other adult was operated upon.

King[25] is an advocate of posterior colpotomy; he reports 3 cases in adult females ranging from 36 to 46 years of age; all 3 cases recovered. He performed posterior colpotomy in 2 cases, but in the third case no exudate was obtained and it was necessary to make an abdominal incision; laparotomy revealed a well-localized abscess involving the right oviduct, ovary, appendix, and cecum. King believes that most cases in females have their origin in the vagina; he further believes that this disease is much more common in adult females than the literature would indicate.

Glazier, Goldberg, and Weinstein[26] report 1 case in a 5-year-old female child who recovered without operation; specific antipneumococcic serum was given credit for the recovery. Diagnosis was based only upon positive blood culture and physical signs of peritonitis.

Hymanson[27] reports an unusual case in a male child 10 weeks of age; there were definite signs of meningitis but no indications of abdominal disease. The child died and autopsy revealed pneumococcic peritonitis and right interstitial pneumonia; the brain and meninges were normal.

Hayden and Dunphy[28] report a case in a female child 6 years of age; on the third day of illness she was operated upon and she died on the sixth postoperative day. These men emphasize the importance of vaginal smears and peritoneal punctures to facilitate early diagnosis.

Sager and Raffel[29] report a case in a 3-year-old colored female; on the second day of illness she was operated upon; because only a small amount of exudate was observed, the wound was closed without drainage. The cultured exudate from the abdomen revealed pneumococci. The chief postoperative treatment was the administration of large doses of prontylin by mouth; the authors believe that the patient's ultimate recovery was due to the prontylin.

Gibson[30] reports 8 cases which were studied only from the standpoint of leucocytosis; he found that the leucocytes varied from 10,000

operated upon during the chronic stage; all of these patients survived. Only 1 vaginal culture was obtained; it revealed pneumococci of the same type as those found in the peritoneal cavity. Perforation of the abdominal wall at the umbilicus occurred in 20 per cent of all cases exclusive of the nephrosis group. Pneumonia and empyema were the most common complications and were very important contributory factors toward death.

Horine[18] reports 7 cases, 4 of which died, giving a mortality rate of 57 per cent; 5 cases demonstrated definite primary lesions, while 2 revealed none. There were 5 females and 2 males. The only fatal cases were those operated upon during the first week of the disease; all cases operated upon during the chronic stage recovered. Horine believes, and rightfully so, that operative intervention prior to definite localization will lead only to disaster and a continued high mortality rate in this disease. Another advocate of late surgery is Ciminata,[19] who reports 8 cases, none of which revealed a primary focus; his mortality rate was 50 per cent. Two patients were operated upon during the acute stage and 2 during the subacute phase; all 4 of these patients died; 4 patients were operated upon during the chronic stage and all recovered.

MacLeod and Farr[20] report 6 cases, all of which were complications of nephrosis; 4 patients died, giving a mortality rate of 66 per cent; the ages were from 2 to 7 years; there were 5 males and 1 female. They found pneumococci of the same type both in the throat and in the peritoneal cavity in all cases. They had been making periodic throat smears on a group of 12 children with nephrosis; 3 of the children who developed pneumococcic peritonitis revealed pneumococci in throat culture before the onset of the peritonitis; in the 3 other cases the throat culture became positive soon after the onset of the peritonitis.

Johnston[21] reports 5 cases, all of which died; the ages varied from 4 to 53 years; there were 3 females, 1 male, and the sex was not stated in the fifth case. Four patients were operated upon during the acute stage and 1 during the chronic phase; the latter patient was operated upon a second time two weeks after the first operation because of the formation of a new abscess; at autopsy an acute process was found at the base of the left lung. This group further strengthens the argument in favor of late surgery.

Bass[22] reports 19 cases covering a twelve-year period at Mount Sinai Hospital; there were 11 deaths, giving a mortality rate of 58 per cent; all cases were females from 16 months to 10 years of age. His mortality rate is exactly the same as that of Schonenberger[23] computed on 376 cases, 214 of which died. Bass reports that 12 of his patients were operated upon and of these 7 recovered; 1 patient underwent spontaneous perforation with recovery. Six patients were not operated upon; all of these died. Blood cultures were secured in 12 cases

and 4 were positive; vaginal cultures were positive in 7 cases. Only 1 patient operated upon in the acute stage recovered; all other patients operated upon in this phase died. Bass emphasizes the importance of vaginal smears and peritoneal punctures as means of making an early diagnosis; he believes that specific antiserum should be given as soon as the type of organism is determined.

Fricke[24] reports 10 cases covering a five-year period at the Lenox Hill Hospital; 8 were children and there were 2 adults. Of the 8 children, 7 were females, and both of the adults were females. Six of the children died and both of the adults recovered, giving a mortality rate of 60 per cent. Six of the children gave a past history of pertussis, an element which Fricke believes to be significant. One of the adults had postabortion peritonitis and was treated with specific serum without operation; the other adult was operated upon.

King[25] is an advocate of posterior colpotomy; he reports 3 cases in adult females ranging from 36 to 46 years of age; all 3 cases recovered. He performed posterior colpotomy in 2 cases, but in the third case no exudate was obtained and it was necessary to make an abdominal incision; laparotomy revealed a well-localized abscess involving the right oviduct, ovary, appendix, and cecum. King believes that most cases in females have their origin in the vagina; he further believes that this disease is much more common in adult females than the literature would indicate.

Glazier, Goldberg, and Weinstein[26] report 1 case in a 5-year-old female child who recovered without operation; specific antipneumococcic serum was given credit for the recovery. Diagnosis was based only upon positive blood culture and physical signs of peritonitis.

Hymanson[27] reports an unusual case in a male child 10 weeks of age; there were definite signs of meningitis but no indications of abdominal disease. The child died and autopsy revealed pneumococcic peritonitis and right interstitial pneumonia; the brain and meninges were normal.

Hayden and Dunphy[28] report a case in a female child 6 years of age; on the third day of illness she was operated upon and she died on the sixth postoperative day. These men emphasize the importance of vaginal smears and peritoneal punctures to facilitate early diagnosis.

Sager and Raffel[29] report a case in a 3-year-old colored female; on the second day of illness she was operated upon; because only a small amount of exudate was observed, the wound was closed without drainage. The cultured exudate from the abdomen revealed pneumococci. The chief postoperative treatment was the administration of large doses of prontylin by mouth; the authors believe that the patient's ultimate recovery was due to the prontylin.

Gibson[30] reports 8 cases which were studied only from the standpoint of leucocytosis; he found that the leucocytes varied from 10,000

operated upon during the chronic stage; all of these patients survived. Only 1 vaginal culture was obtained; it revealed pneumococci of the same type as those found in the peritoneal cavity. Perforation of the abdominal wall at the umbilicus occurred in 20 per cent of all cases exclusive of the nephrosis group. Pneumonia and empyema were the most common complications and were very important contributory factors toward death.

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the vaginal exudate. The patient was immediately given 20,000 units of Type V antipneumococcic serum intravenously; this injection was repeated every four hours until 120,000 units had been administered. During the next twenty-four hours, 20,000 units were given intramuscularly every four hours until an additional 120,000 units had been given.

Fifty-two hours after admission, the patient developed dyspnea, cyanosis, and coarse crepitant râles over the entire chest; there was a sudden rise in sublingual temperature from 102.6 to 105° F. and the pulse rate became elevated from 126 beats per minute to 154 beats. A bedside chest roentgenogram revealed bilateral diffuse bronchopneumonia; the patient soon developed a cough which produced a mucosanguineous sputum; this sputum was found to contain Type V pneumococci. Immediately after the onset of pneumonia, serotherapy was resumed to the extent of 120,000 units over a twenty-four-hour period; the patient was also given two high frequency radiations of the chest each day. Because of the large amount of fluid in the alveoli, the volume fluid intake was diminished by substituting 50 c.c. of 50 per cent glucose for the liter of 5 per cent solution. Transfusions of 300 c.c. of whole blood were given every other day.

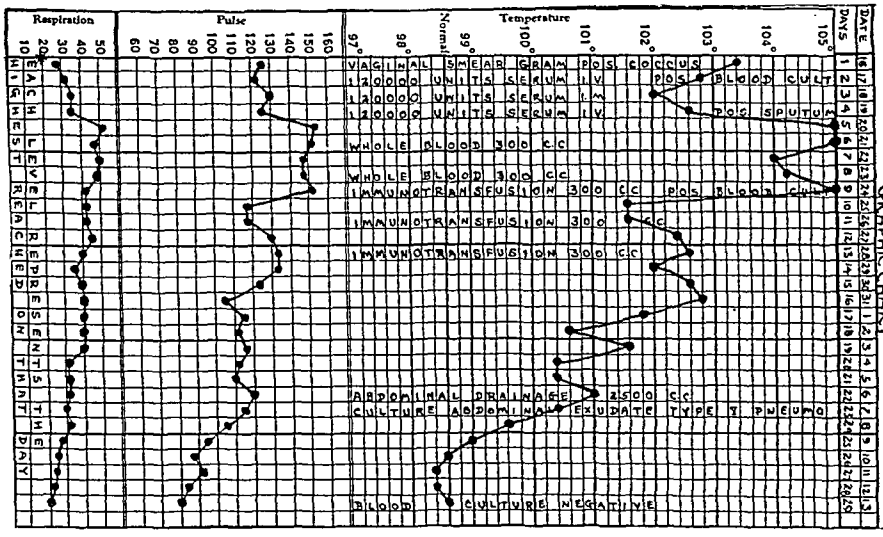


Fig. 1.

The right lung responded well to treatment, but five days after the onset of pneumonia the left lung developed distant breath sounds and a flat percussion note; a roentgenogram displayed left pleural effusion and patchy pneumonitis of the left lung; the right lung revealed no pathology. At this time the blood culture again showed Type V pneumococcus and the carbon-dioxide-combining power of the blood was 58 volumes per cent. On this day the patient became moribund and it became evident that more drastic treatment was necessary if death was to be averted. Several cases of bacteremia had previously been saved by use of the controlled non-specific immunotransfusions of Crocker, Valentine, and Brody[13] so it was decided to attempt this form of treatment. A suitable donor was given one hundred million killed typhoid bacilli intravenously and fifty million were injected one hour later. At the end of seven hours his sublingual temperature was 104.2° F. and his blood revealed 40,000 leucocytes per cubic millimeter; at this time 300 c.c. of blood was withdrawn and injected into the patient. Within twenty-four hours there was a dramatic response and the patient roused from her moribund state; two more of

to 50,000 per cubic millimeter of blood and that the polymorphonuclear leucocytes represented 87 to 97 per cent of the total count. He believes that both the leucocyte count and polymorphonuclear percentage are sufficiently high in pneumococcic peritonitis to be diagnostic. He reports control cases to illustrate the difference between pneumococcic and other forms of peritonitis.

TYPICAL CASE REPORT

The patient, a white, unmarried, female stenographer, 18 years of age, was admitted to St. Paul's Hospital by ambulance on May 16. Her chief complaint was severe cramping pain in the lower abdomen. From May 8 to May 13 she had experienced a menstrual period which was normal in amount, duration, and cycle. Twenty-four hours after menstruation ceased, bleeding was resumed; the hemorrhage was profuse and many clots were passed. This bleeding was accompanied by increasingly severe lower abdominal pain; there was nausea but no emesis. There had been a moderately profuse vaginal discharge for three days previous to the onset of the last menstruation; there had been no previous vaginal discharge and all previous menstrual periods had been normal in amount, duration, and frequency. There were no other symptoms associated with the present illness and the past history was irrelevant.

Examination revealed a well-developed and well-nourished patient lying quietly in bed; she displayed an anxious facies and was obviously acutely ill. The sublingual temperature was 103.4° F. and the pulse rate was 126 beats per minute. The blood pressure was 104 systolic and 62 diastolic. Systems above the diaphragm failed to reveal any evidence of pathology. The abdomen revealed a board-like rigidity, which was graded four, and diffuse tenderness, graded four; distention was graded only one. Because of the extreme rigidity, no viscera were palpable. Vaginal examination revealed total absence of the hymen; the cervix was soft and semipatulous. Abdominal rigidity prevented adequate bimanual examination. The vagina exuded a dark, serosanguineous fluid, a specimen of which was collected for smear and culture. The smear revealed a predominance of gram-positive lancet-shaped diplococci and the culture produced a pure strain of Type V pneumococcus. Blood count on admission revealed 10.5 gm. of hemoglobin per cubic centimeter; there were 4,040,000 erythrocytes and 7,040 leucocytes per cubic millimeter; 92 per cent of the total leucocytes were polymorphonuclear cells. The color index was 0.9 and the nuclear index was 3.6. A catheterized urine specimen showed albumin, graded one; microscopic examination displayed pus cells, graded one; finely granular casts, graded four; and hyaline casts, graded one. The sedimentation rate was 117 mm. at the end of one hour; the erythrocytic volume pack was 37 c.c. per 100 c.c. of blood. The blood Wassermann, Kline, and Eagle tests were negative.

When the vaginal smear displayed bacteria having the morphology of the pneumococcus, it was decided to assume that the patient was suffering from pneumococcic peritonitis; without waiting for the results of the culture, treatment was begun accordingly. Because of the excessively high mortality rate in early surgery on this type of case, it was quickly decided to postpone abdominal drainage until it was positive that localization was complete. However, while awaiting this localization, the patient was rapidly becoming moribund; therefore, rather heroic treatment was begun while awaiting results on cultures of blood and vaginal exudate.

A Levin type duodenal tube was introduced and continuous suction established; 1 L. of 5 per cent glucose in isotonic saline solution was given intravenously every eight hours. Forty-eight gr. (3.2 gm.) of prontylin in 400 c.c. of isotonic saline solution was given subcutaneously every twelve hours. Twenty-four hours after admission, a type V pneumococcus was found in cultures from both the blood and

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these immunotransfusions were given at forty-eight-hour intervals. Following these transfusions, the patient made a very spectacular improvement. On June 6, three weeks after admission, the abdomen was distended to grade four and had a consistence sometimes described as doughy; there was no longer any frank rigidity present. It was felt that the exudate was well localized so a 1 inch (2.5 cm.) incision was made in the midline just below the umbilicus; 2,500 c.c. of thick purulent exudate was withdrawn and two Penrose drains were inserted. The peritoneal exudate produced a pure culture of Type V pneumococcus.

On June 13 the patient's condition was good; the temperature and pulse were normal, and the abdominal incision was draining well. Roentgenogram of the chest revealed only a small amount of fluid at the left base; the blood culture was negative for the first time. The patient was returned to her home on this date under close observation.

On July 14, approximately two months after onset, the sublingual temperature was 101.6° F. and the pulse rate was 132 beats per minute; the abdomen was scaphoid and displayed no tenderness, rigidity, fluctuation, or masses. The entire left chest revealed a flat percussion note and absence of breath sounds; the mediastinal contents were displaced to the right. The left pleural cavity was aspirated and 640 c.c. of thick purulent exudate was withdrawn. A No. 18 catheter was placed in the pleural cavity through the space between the sixth and seventh ribs in the postaxillary line and sutured in place. This pleural exudate produced a pure culture of Type V pneumococcus. The chest drained during the following five weeks, after which time the patient made an uneventful recovery; she has consistently gained weight and has enjoyed excellent health since her illness.

SUMMARY

The present status of pneumococcic peritonitis has been reviewed and a typical case presented; this case was carefully followed both from a clinical and a laboratory point of view. The Type V pneumococcus was first found in the vaginal exudate during the existence of an acute generalized peritonitis; these organisms were then found in the sputum, blood, and later in the abdominal and pleural exudates.

There has been employed a new treatment, the use of which has never before been reported in pneumococcic peritonitis. It is earnestly and profoundly felt that this treatment, controlled nonspecific immunotransfusions, was solely responsible for the recovery of this patient; she not only failed to improve under prontylin and specific serotherapy but actually became worse during their use.

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TABLE I

EXPERIMENTS ON DOGS*

EXPERIMENT NO.	WEIGHT IN KG.	MATERIAL INJECTED C.C.	DEGREE OF PANCREAS EDEMA	TIME IN HR.	ENZYME CONCENTRATIONS IN EDEMA FLUID		ENZYME CONCENTRATIONS IN PERITONEAL FLUID		ENZYME CONCENTRATIONS IN BLOOD SERUM	
					AMYLASE	LIPASE	AMYLASE	LIPASE	AMYLASE	LIPASE
1	7.5	0.1 gbb.†	++	¼	8,000					
2	20.0	0.1 gbb.	+++	Control						
				¼					32	
				1	2,500		320			
				2			640		64	
3	22.5	0.1 gbb.	+	¼	800				64	
4	18	1.5 gbb.	++	¼	750	0.99‡				
5§	10	1.5 gbb.	+	¼	50,000					
6	10.5	1.5 olive oil	+	¼	256	1.2				
7	12	1.5 liver bile	++	Control						
				¼						
				1	4,000	0.8				
				2						
8	20.0	3 liver bile	+++	Control			2,000	3.0	64	
				1			2,000	1.5		
				2					64	
				3			512	2.2	64	0.5
				4			2,000		64	
				5			6,000	2.4	256	
							1,000	2.2	256	1.0
							+1,000	2.4	512	1.2
										1.45

*Amylase was estimated by the Wohlgemuth method;[9] lipase by the Crandall and Cherry method;[7] and trypsin by Anson and Mirsky method.[8] The ferment concentration is expressed: amylase in Wohlgemuth units ($\frac{d\ 38}{30}$); lipase in c.c. n/20 Na OH; and trypsin in mg. tyrosin.

†Gall-bladder bile.

‡Trypsin, 0.08.

§Pancreatic secretion stimulated by secretin.

ENZYME STUDIES IN EDEMA OF THE PANCREAS AND ACUTE PANCREATITIS

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THE clinical picture of edema of the pancreas was observed first by Archibald[1] and described as clinical entity by Zoepffel.[2] Some observers believe that edema of the pancreas is an inflammatory process, associated usually with infections of the biliary system, while others see in it a precursor of pancreatic necrosis; in other words, the diverging opinions represent the concept of inflammation with or without infection versus the concept of fermentative changes.

Archibald believes that edema of the pancreas represents an inflammatory but not an infectious process, like an aseptic inflammation following injection of croton oil.[3]

Edema of the pancreas can easily be produced in animals. A few minutes after the injection of bile or some other substances into the pancreatic duct an interstitial edema appears which spreads very quickly over the pancreatic gland and reaches its maximum in fifteen to thirty minutes after injection. This amazingly fast spreading of the process is hardly compatible with the assumption of an inflammatory basis. The question rather arises whether we may not be dealing with a diffusion of pancreatic juice in consequence of intrapancreatic activation of enzymes.

Mann and Giordano[4] and Rich and Duff[5] believe that injections into the pancreatic duct rupture ductules and acini, thereby permitting pancreatic juice to diffuse into the interstitial tissue of the gland and to produce inflammation. We have met their objections and believe we have disproved them.

The following experiments were performed to study this problem: Pancreatic edema was produced in a series of dogs by injection of gallbladder bile, liver bile, or olive oil in amounts of 0.1 to 3 c.c. into the main pancreatic duct and subsequent ligation of the duct. In each case a marked interstitial and subcapsular edema of the pancreatic gland appeared rapidly. About fifteen minutes after injection, a few drops of subcapsular fluid were aspirated after the capsule had been perforated very carefully, avoiding injury to the gland itself.

The analysis of the aspirated fluid revealed in each case a considerable amount of amylase and of lipase. Trypsin was estimated in one instance only and was found to be present.

One hour after injection of the pancreatic duct, a bloody fluid was found in the abdominal cavity of these dogs, which increased in amount

Received for publication, September 28, 1929.

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§Pancreatic secretion stimulated by secretin.

as time progressed. The appearance of this exudate was noted in experiments in which the capsule of the pancreas was not incised, as well as in experiments in which it had been perforated for aspiration of subcapsular edema fluid. An analysis of this exudate was performed in three cases and revealed the presence of high concentrations of amylase and lipase (Table I). These enzymes of the peritoneal fluid might be derived directly from the pancreas due to further diffusion of pancreatic juice or they might be due to an increased concentration of enzymes in the exuding blood and serum.

Serum amylase was determined in Experiments 2, 7, and 8; no remarkable changes were noted within two hours in Experiments 2 and 7. In Experiment 8 serum amylase and lipase were followed over five hours and both showed distinct increases, due evidently to gradually increasing pathologic changes of the pancreas which could be observed in the course of the experiment. However, the rise of amylase and lipase values in the blood did not reach by far the enzyme concentrations found in the exudate and began after two hours, while the rise in the exudate became apparent after one hour. This shows that the enzyme contents of the peritoneal fluid could hardly be derived from the blood, but originated from the pancreas itself.

Artificially produced edema of the pancreas in dogs offers very much the same pathologic picture as in man. It seems reasonable therefore to assume that in man also pancreatic edema may be produced by intrapancreatic activation and consequent diffusion of pancreatic juice and that, as in the dog, the edema fluid will contain pancreatic enzymes. This has not been investigated as yet.

Since edema as well as necrosis of the pancreas seems to develop as a consequence of intrapancreatic activation of pancreatic enzymes, we may assume that in both instances a diffusion of pancreatic juice into the peritoneal cavity may occur. I have been able to prove this in operative cases of pancreatic disease in man.

A high concentration of amylase was found in the peritoneal fluid of each of nine cases I operated upon. Two of them had edema of the pancreas, four had acute pancreatitis with fat necrosis, and three had a hemorrhagic necrosis of the pancreas.

DISCUSSION

We believe that such small amounts of fluid as 0.1 c.c., i.e. 2 drops, cannot possibly rupture ductules or acini. Rich and Duff used amounts of 3 to 10 c.c. of fluid, amounts which seem so large that we agree that physical damage to the gland may be produced by them. The above authors point to the fact that Archibald had been unable to produce changes of the pancreas by injection of 0.75 c.c. of bile into a pancreatic duct, and they feel, therefore, that larger amounts of bile produce edema, etc., by physical damage to the gland. As main proof

for their contention, they showed that India ink injected into a pancreatic duct in amounts of 3 c.c. and more could be seen in the interstitial tissue in microscopic sections. We have convinced ourselves that microscopic study of such preparations is inconclusive because India ink is spread over the tissue during the process of sectioning. We cannot explain why Archibald did not obtain changes of the pancreas with 0.75 c.c. of bile, while we were able to produce edema with 0.1 c.c. only; but we feel that Rich and Duff are wrong in their assumption that bile damages the pancreas through the primary physical damage of injection. Since pancreatic enzymes were found regularly in the edema fluid of the pancreas and in the peritoneal exudate, we must assume that a diffusion of pancreatic juice occurred through cell membranes, normally impermeable to it. It is probable that physicochemical changes of the pancreatic ferments are responsible for this diffusion.

TABLE II

HUMAN PERITONEAL EXUDATE

CASE NO.	PATHOLOGIC CONDITION OF PANCREAS FOUND AT OPERATION	PERITONEAL EXUDATE AMYLASE	BLOOD AMYLASE
1	Edema	2,000	128
2	Edema	8,000	1,000
3	Acute pancreatitis with fat necrosis	256	32
4	Acute pancreatitis with fat necrosis	8,000	512
5	Acute pancreatitis with fat necrosis	1,000	64
6	Acute pancreatitis with fat necrosis	512	32
7	Hemorrhagic necrosis	4,000	256
8	Hemorrhagic necrosis	256	32
9	Hemorrhagic necrosis	2,000	128

The above observations are in line with previous experiments and observations of mine[9, 10] which showed that reflux of pancreatic juice into the biliary system may be followed by diffusion or transudation of an activated mixture of pancreatic ferments and bile through the intact walls of the gall-bladder and bile ducts into the peritoneal cavity (Popper[7, 8]).

SUMMARY AND CONCLUSIONS

In artificially produced edema of the pancreas of dogs high concentrations of pancreatic enzymes were found regularly in the subcapsular edema fluid of the pancreas. Edema of the pancreas seems to be due to diffusion of activated pancreatic juice through the intact ducts into the tissues of the pancreas, and not to mechanical rupture of ducts, etc. Large amounts of amylase and lipase were demonstrable in the peritoneal exudate some time after the development of pancreatic edema.

Activated pancreatic juice obviously diffuses into the interstitial tissue of the gland first and later on into the peritoneal cavity. These

same conditions seem to exist in human pathology since in every one of a number of cases of acute pancreatic disease in man examined by me, a high amylase concentration was found in the peritoneal exudate.

The author gratefully acknowledges advice and help from Drs. H. Necheles, F. Neuwelt and E. Spier from this department, and from Drs. D. J. Cohn and I. Kaplan from the Department of Chemistry.

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DIFFUSION OF PANCREATIC ENZYMES THROUGH THE INTESTINAL WALL IN ILEUS

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IN PREVIOUS observations on man I have been able to demonstrate that under certain conditions the extrahepatic biliary system may become permeable to bile and pancreatic juice after the latter has entered it by reflux.[1-3] Following this work it seemed natural to investigate whether a mixture of bile and pancreatic secretion, such as would accumulate in the duodenum under conditions of obstruction, would penetrate through the living, unperforated duodenal wall.

The method of our experiments was as follows: In five dogs the duodenum was ligated under nembutal anesthesia just below the pylorus and somewhat below the junction of the accessory pancreatic duct. Thus the portion of the duodenum which contained the openings of bile and pancreatic ducts was shut off from the rest of the intestines without interference with the blood supply. The secretion of pancreatic juice and of bile was then stimulated by intramuscular injection of mecholyl, decholin,* or eserine. The experiment was continued for five to seven hours. At that time the loop was distended and its serosa slightly congested. The loop was excised and opened. It was filled with bile-stained fluid. Its wall and mucosa appeared grossly normal. Histologic examination revealed infiltration of the intestinal wall with round cells, but did not show necrotic or acute inflammatory change and the epithelial lining of the mucosa appeared normal. Neither pancreas nor liver showed any change.

TABLE I

EXPERIMENT NO.	ENZYME	CONCENTRATION IN EXUDATE AFTER					CONCENTRATION IN SERUM AFTER				
		1 HR.	2 HR.	3 HR.	5 HR.	7 HR.	0 HR.	1 HR.	3 HR.	5 HR.	7 HR.
1	Amylase*				1,000		64			256	
2	Amylase			2,000	4,000	512	32			256	
3	Amylase		32		64	64	64	64	64	64	64
4	Amylase		256								
5	Amylase	64		2,000	512	512	32	64	256	256	256
	Lipase†	1.2		2.05	1.45					0.2	

*Wohlgemuth method ($d\ \frac{38}{30}$).[5]

†Crandall and Cherry method.[6]

Received for publication, September 28, 1939.

*We acknowledge gift of these substances by Merck & Co. and Riedel de Haen respectively.

Two to three hours after the beginning of the experiments, a varying amount of markedly bloody exudate was found in the peritoneal cavity. Determinations of enzymes in the aspirated fluid revealed relatively high concentrations of amylase in Experiments 1, 2 and 5. In Experiment 3 no increased value of amylase was found. In the latter animal the stomach was filled up with undigested foodstuffs, although it had been fasted for sixteen hours; this animal probably was sick. A moderate increase of amylase was found in Experiment 4 already after two hours, but the animal died a short while later, probably due to overdosage of mecholyl.

Determinations of trypsin were not practicable on account of admixture of blood. Only a few determinations of lipase were performed. The presence of high concentrations of amylase was considered to be sufficient to indicate the presence of pancreatic secretions.

Amylase was also determined in venous blood which was drawn at the beginning of each experiment, and in Experiments 1 and 2, five hours, in Experiments 2 and 3, one, three, five, and seven hours after beginning of duodenal obstruction. In Experiments 1, 2, and 5, in which diffusion of pancreatic enzymes into the peritoneal cavity was demonstrable, a moderate increase of blood amylase was found which, however, by far did not reach the value found in the peritoneal exudate. It is interesting to note that in Experiment 3, which did not show an increase of amylase in the exudate, likewise no increase of blood amylase was found.

The question arises what the cause of the increase of blood amylase may be. Since neither gross nor microscopic changes were found in the pancreas, we are inclined to assume that the increase of amylase in the blood is caused by absorption of pancreatic enzymes from the bloody exudate in the peritoneal cavity into the lymph or blood stream; this assumption is supported by the results of Experiment 3. Further research is directed to answer this question.

The findings reported in this paper may throw light on the old question of the mechanism of the increase of pancreatic enzymes in the blood in acute pancreatic diseases. Everybody who had occasion to observe a great number of cases of acute pancreatitis knows that those cases with more peritoneal exudate generally have higher concentrations of amylase in the blood than the more "dry" cases (Walzel).

SUMMARY AND CONCLUSIONS

In five dogs complete obstruction of the duodenum was produced by ligatures just below the pylorus and below the duct of Santorini. The secretion of bile and pancreatic juice was stimulated by drugs. Although the obstructed duodenum was distended, its tissues were not devitalized nor did perforation occur. Pancreas and liver were found

to be normal. Bloody peritoneal exudate contained large amounts of amylase in most animals. Blood amylase gradually increased during the course of obstruction, but it did not reach the values found in the peritoneal exudate. Like in the case of permeability of an intact gall bladder after injection or reflux of pancreatic juice, the intact intestinal wall is permeable to pancreatic enzymes in the case of experimental obstruction. The bearing of these observations on high ileus in the human is evident.

The author gratefully acknowledges advice and suggestions from Dr. H. Necheles.

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THE EFFECT OF PREDIGESTED FOOD ON EXPERIMENTAL PEPTIC ULCER

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THE concept that peptic ulcer depends upon some nutritional disturbance or some as yet unknown deficiency seems to have fully as much experimental support as other well-known theories. Weech and Paige[4] found that, of twenty-two dogs which were kept on a low protein diet in a study of nutritional edema, 36 per cent developed a true peptic ulcer. An additional 23 per cent showed superficial erosions of the gastric and duodenal mucosa. Bollman and Mann[1] reported that many animals on which Eck fistulas were produced ultimately died of a peptic ulcer. Furthermore, many experimental procedures designed to test the effect of an unneutralized acidity interfere with the intestinal physiology which, in turn, may alter the animal's nutrition.

It is obvious that drainage of the entire duodenal contents into the lower ileum or exteriorizing the biliary and pancreatic ducts must seriously affect digestion. The ingenious method of Matthews and Dragstedt,[3] by which the gastric juice was conducted through a rubber tube for a distance down the jejunum, would seem to disturb digestion less than many other studies. However, it does not eliminate the possibility that some factor is deranged by the failure of the stomach contents to mix with the other juices at a high level in the tract. Other experiments planned to avoid a disturbance in nutrition produce one or both of two distinctly abnormal conditions: a complete inability of the gastric juices to be neutralized normally, a condition not proved to occur in man; the hydrochloric acid is brought into contact with a portion of the intestines which does not normally receive it. Therefore, a summary of the evidence shows that most of the experimental procedures which produce an ulcer analogous to those which occur in man inject one or more of three phases foreign to man into the situation.

Clinical studies of patients with peptic ulcer do not conflict with the experimental observations. The cyclical behavior of the disease is no different from that of pernicious anemia. The failure of clinicians to recognize any gross disturbance in nutrition would not seem to rule

Received for publication, September 20, 1939.

out a deficiency as an etiological factor when one considers the prolonged failure to recognize a disturbance in nutrition in such deficiencies as pernicious anemia and beriberi. The fact that there appears to be an ulcer diathesis and some evidence that the disease runs in families is as compatible with the theory of a disturbance in nutrition as with the other suggested causes. Therefore, it seems reasonable to consider the question of nutrition more thoroughly.

It appeared desirable to study this hypothesis by trying to correct the disturbance in digestion resulting in dogs upon which surgical drainage of the duodenum has been performed. That this might be overcome if the animals were given food which had gone through all the normal processes of digestion in the upper intestinal tract of control animals was our premise. Our first problem became one of devising a means for obtaining such food. After several attempts, one of us (R. Z.) contrived a form of fistula which would permit the insertion of a tube in the duodenum of an otherwise normal animal.[5] By this means we were able to obtain sufficiently large quantities of chyme to supply the dogs on which Mann-Williamson operations had been performed.

METHODS OF STUDY

As a preliminary step, high jejunal fistulas were made in three dogs. After the wound had sufficiently healed and the dogs were eating the regular kennel diet of horse meat and bread, food was removed from the jejunum in the following way. The animals were brought into the laboratory and given a quart of milk containing 450 gm. of a prepared dog food, known as checkers. Checkers was used because it is a complete food and because it could be broken into such small pieces that it rarely plugged the aspirating tube. From thirty minutes to one hour after completion of the meal, a tube 11 mm. in diameter was inserted through the fistula into the jejunum. Mild suction was instituted by means of siphon drainage, and the material was aspirated into a bottle. Usually from 300 to 1,000 c.c. could be collected after one meal. The material was alkaline to litmus and was brown in color due to the bile that it contained. The chyme was then stored in the icebox until it was needed to feed the experimental dogs.

After a sufficient amount of this material was at hand, four Mann-Williamson dogs were prepared. These animals were in good health at the time of operation and averaged about 14 kg. in weight. The general routine was the same in all experiments. Approximately one week after operation small feedings of ground horse meat and bread were begun. To this diet supplemental feedings of milk and jejunal chyme were added. Because the animals frequently objected to this food, it was necessary to omit the chyme from time to time and give milk or meat to prevent the animal's losing an undue amount of weight. When anorexia became pronounced, they were fed milk and jejunal juice through a stomach tube.

THE EFFECT OF PREDIGESTED FOOD ON EXPERIMENTAL PEPTIC ULCER

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Received for publication, September 20, 1939.

DISCUSSION

A perusal of these data shows that the giving of considerable quantities of predigested food appears to have no beneficial effect on the course of the animals on which surgical drainage of the duodenum has been performed. In fact, they failed more rapidly than the usual control Mann-Williamson dog. The four animals lived an average of 8.4 weeks in comparison to an average survival period of 17 weeks reported by Fauley and Ivy[2] for forty-two dogs operated upon by the Mann-Williamson technique and fed a stock diet.

In an attempt to evaluate these results, certain facts should be considered. First, all of the animals varied considerably in their attitude toward food from the very beginning. Two seemed to eat well, even though they lost weight, and their appetites did not begin to fail until after their general condition had become poor. The other two showed a tendency to refuse the diet from the start and were always feeding problems. It is possible that this variation in their attitudes toward food may be explained by the mechanical behavior of the stomach and intestine after the operation is performed. It also is true to some degree that the animals with the best appetites, in general, got along the best until the final days when all went through the same rapid decline.

The second point of interest is that the general course of these animals is much the same. There is a period of time after the operation when they are in good condition. Then comes a second period when the animal is losing weight and shows evidence of inadequate nutrition even though his appetite may be good. At the third stage his appetite fails. The fourth and final stage occurs when evidence of an active ulcer develops, usually signified by the presence of gross blood in the stool.

The third observation is that there is a definite change in the body as far as the protein and some salts are concerned. In two dogs three determinations of the blood proteins were made as long as forty-eight and fifty days after operation. There was a gradual decline in these levels from an average of 6.2 to 3.7 mg. per cent. But the anemia which is always present at the end seems to depend on the loss of blood rather than on the inadequate nutrition. There can be no denying the fact that the Mann-Williamson operation produces an inadequate nutrition in addition to preventing normal neutralization of the gastric juice. The question then arises as to which of these two factors is essentially the more important. It is recognized that the type of experiment which Mann and Williamson first introduced has demonstrated the close association between the hydrochloric acid and the development of a lesion. However, this does not mean that an unneutralized acid is the sole cause of an ulcer in man; nor, so far as we are aware, have these investigators made this contention. Clinical

EXPERIMENTAL DATA

Because each of the four animals used behaved somewhat differently, it is necessary to discuss them individually.

The first dog (No. 1-38) lived for a total of forty-four days, but seemed to do poorly from the beginning, showing little desire to eat at any time. After having refused all food, the dog regained his appetite temporarily on the sixteenth postoperative day, although this was the first day that a black stool was found in its cage. It refused food repeatedly and required feeding by stomach tube, so received much less of the predigested food than the other dogs. It lost weight, declined, and died on the forty-fourth postoperative day. At autopsy the operative wound and anastomosis were found to be in good condition; the junction between the stomach and jejunum was patent; and there was a large jejunal ulcer just distal to the line of sutures.

The second dog (No. 4-38) lived for eighty-nine days and, except for one setback early in its course, ate well, and was the most satisfactory experiment. From 50 c.c. of predigested food given on the seventh postoperative day, the amount was rapidly increased to 450 c.c. Because the dog was losing weight, its diet was increased on the twenty-third postoperative day by adding ground horse meat, milk, and corn syrup. This so upset the animal that the predigested food was omitted. Upon the return of its appetite a week later, the dog averaged 200 to 400 c.c. of predigested food daily until death on the eighty-third day. At autopsy extensive penetrating ulcers were found just distal to the anastomosis.

The third dog (No. 18-38) lived a total of fifty-seven days. On the seventh postoperative day it was started on 100 c.c. of the predigested food plus one quart of milk. At the end of four days the predigested food was increased to 200 c.c. Eleven days later because of a failing appetite the predigested food was decreased to 100 c.c. a day which it took fairly regularly until death supervened thirty-five days later. During most of the time, the dog appeared to do well and to have a reasonably good appetite. However, twenty-eight days postoperatively its appetite suddenly waned. During this time its diet was varied a good deal with the hope that it would be encouraged to start eating again, but the last six days of its life it refused to take any food. Autopsy in this animal showed two large penetrating ulcers in the jejunum adjacent to the line of anastomosis, one of which had perforated and had been sealed off by omentum.

The fourth dog (No. 19-38) lived a total of forty-eight days. It always showed a dislike for the predigested food and ate very little during the first twenty days. It then began to eat food which was not mixed with the gastric juice so that the predigested food had to be given by stomach tube. It went downhill rapidly and at autopsy showed a large superficial ulcer of the jejunum near the pylorus.

A TECHNIQUE FOR HIGH INTESTINAL FISTULA

Experimental Method

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RECOVERY of the intestinal secretions over a period of time is desirable in certain laboratory investigations. But since the continued loss of fluids from a high intestinal fistula results in the almost immediate death of the animal, a method which maintains communication with the intestine yet permits retention of its contents, except when aspirated, is vital for any prolonged investigation.

Mann and Bollman[1] have described a procedure for establishing a nonleaking fistula of the small intestine. However, in some recent laboratory experiments in which it was necessary to obtain large quantities of intestinal juice from a point just distal to the duodenum, this method did not fulfill our requirements. We could neither be certain that the drainage tube entered toward the stomach nor could we obtain a sufficient quantity of material. Therefore, we devised a simplified method for establishment of a fistula which was so suitable for our needs that we believe it will prove useful to other investigators.

If a fistulous opening from the stomach is placed near the midline of the back, no secretions are lost because an animal, even at rest, will maintain the opening uppermost. Taking cognizance of this observation by Cope,[2] we planned our operation.

All experiments were carried out under intravenous nembutal anesthesia and sterile conditions. Fine silk suture material was used throughout.

The abdomen was opened, and the ligament of Treitz was divided to mobilize the jejunum. A loop of intestine was then selected at the desired level for the fistula. A lateral anastomosis with a stoma approximately 5 to 6 cm. in length was performed within 5 cm. of the apex of the loop. The loop of intestine beyond the anastomosis was pulled through a stab wound made high in the left flank as far posteriorly as possible. Since high jejunal fistulas, when similarly placed on the right side, were found unsatisfactory because of the continued loss of secretions, the left flank was always used. An opening was made in the mesentery beyond the anastomosis, allowing part or all of the abdominal wall to be approximated through this rent in order

Received for publication, September 20, 1939.

observations of patients also support the idea that acid is a factor in producing the ulceration in man, but our recent knowledge of peptic ulcer refutes the thought that it is the only, or perhaps the main, cause of human ulceration. Moreover, it usually takes several weeks before the ulcer develops in the experimental animal so that some protective function of the mucous membrane must be lost before ulceration actually develops.

The failure of our experiments to prevent the formation of an ulcer or to prolong the animals' lives does not, of course, disprove the hypothesis which led us to perform these experiments. It is possible that the operation causes the loss of some substance or substances in greater amounts than the normal dog can manufacture from the usual diet. The observation of Fauley and Ivy that a specially prepared diet which, among other things, includes liver and raw pancreas, prolongs the lives of these animals makes it seem possible that the intestinal tract is capable of some digestion and absorption. It might have been of interest to determine what effect the giving of this diet in a predigested form would have had on the experimental animals. Another possibility is that a disturbance in nutrition may arise in the liver or some other organ after actual absorption of food from the tract, which, of course, was not taken into account in these experiments.

SUMMARY AND CONCLUSIONS

Some clinical and laboratory studies have suggested that peptic ulcer may depend upon a disturbance in nutrition. As one way of testing this hypothesis, four dogs upon which a surgical drainage of the duodenum had been performed, as originally devised by Mann and Williamson, were given considerable quantities of food obtained from the upper small intestine of normal dogs. This treatment failed to prolong the expected postoperative course of the animals. However, the fact that Fauley and Ivy have been able to prolong the lives of similar animals with a specially prepared diet suggests that further work along these lines is indicated.

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depending upon the amount fed the animal. Daily intubation proved unwise, because it occasionally initiated bleeding from the fistulous opening.

Following several months of study, some scarring occurred around the opening with resulting constriction, but this did not interfere with continued aspiration. The animals continued in good health.

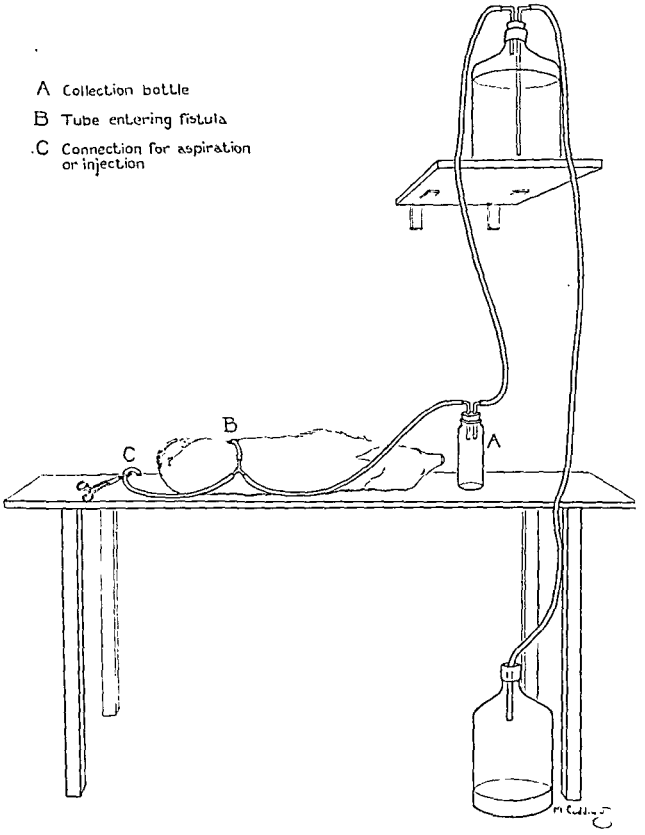


Fig. 2.—Method of obtaining intestinal contents from fistulous opening by means of siphon suction.

CONCLUSIONS

A simplified technique for the establishment of an intestinal fistula has been described. Such a nonleaking fistula permits withdrawal of a fraction or all of the intestinal secretions at the desired level over a prolonged period of time.

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to prevent the subsequent retraction of the fistulous opening (Fig. 1). The remainder of the wound was brought together loosely about the intestine to avoid interference with its blood supply. The original abdominal incision was carefully closed. The exteriorized intestine was covered with sterile gauze and saturated with collodion.

Because it is unnecessary to divide the ligament of Treitz except for a high jejunal fistula, a loop of intestine for a lower level fistula may be delivered primarily through a stab wound in the left flank without the necessity of an initial abdominal incision. Usually an adequate length of intestine can be mobilized for the performance of a lateral anastomosis and the steps previously described.

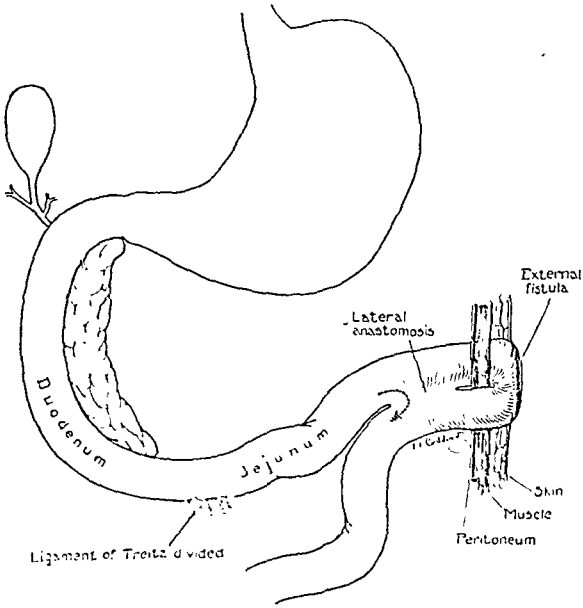


Fig. 1.—Schematic drawing showing fixation of the fistulous opening and the location of the lateral anastomosis.

Seven to ten days following operation, after the wound was well healed, an incision of sufficient size to permit the introduction of a rubber tube as large as 11 mm. in diameter was made in the exteriorized intestine. Only a minimum of drainage occurred at any time from the fistulous opening.

Several days later we proceeded to aspirate the duodenal contents. The dogs were fed milk and checkers (a prepared dog food) about one-half hour before collection was planned. At the time of collection an open-end rubber catheter with several side openings was introduced into the fistulous opening. Through this, mild suction was maintained by the siphon method shown in Fig. 2. The flow of intestinal contents started almost at once and continued until as much as 800 c.c. of duodenal contents were removed in forty-five to sixty minutes.

the peritoneal cavity. Although I have found to date no mention in the English literature of the use of the peritoneoscope in such cases, it seems that there could be no more clear-cut or practical indication for the procedure. Peritoneoscopy is a safe, minor operation, performed under local anesthesia through a stab wound scarcely bigger than that used in the familiar "belly tap." Yet, with but rare exceptions, it is as dependable as a laparotomy in determining the presence or absence of perforation.

Peritoneoscopy (also termed abdominoscopy, celioscopy, laparoscopy, ventroscopy, etc.), first described and practiced upon dogs by Kelling, of Dresden,[8] in 1901, was by 1910 employed upon human beings by both Kelling[9] and Jacobaeus,[10] of Stockholm. In this country it has been little used until rather recently. Perhaps the greatest impetus to its general acceptance in America has been given by Ruddock.[11] By 1937 he had devised a very efficient instrument* and had reported a series of 500 observations with but 1 fatality and with a diagnostic accuracy of 91.7 per cent. Benedict,[12] Thieme,[13] Horan,[14] and others have also recently contributed series of safe and accurate abdominal diagnoses by this method.

INDICATIONS AND LIMITATIONS

Peritoneoscopy is indicated only in those cases of gunshot or stab wounds in which doubt exists whether or not the peritoneal cavity has been penetrated and in which the entry wound, if present, would be within reach of the scope's vision. The entire front wall of the abdomen around to about the midaxillary line on each side and much of the undersurface of the diaphragm can be visualized.

Wounds through the back and up behind the stomach are inaccessible. Fortunately, as pointed out above, few of them are in these latter locations.

Peritoneoscopy is contraindicated where the patient is in desperate condition or where perforation is obvious. Also, this procedure is ill advised in chest injuries suspected of perforating the diaphragm above the costophrenic sinus, because in such cases the air introduced into the abdomen might easily leak up into the pleural cavity. If peritoneal perforation is disclosed, laparotomy is then in order.

TECHNIQUE

A foroblique cystoscope and simple accessories (Fig. 1) proved satisfactory in the five cases here reported. Such instruments should be available even to small hospitals. However, we now use the Ruddock peritoneoscope and find its visibility and range far superior to the cystoscope.

*The Ruddock peritoneoscope, manufactured by American Cystoscope Makers.

PERITONEOSCOPY IN GUNSHOT AND STAB WOUNDS OF THE ABDOMEN

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IT IS established surgical practice to explore, with rare exceptions,[1] any gunshot or stab wound of the abdomen suspected of entering the peritoneal cavity.[2-5] In borderline cases the decision whether or not to operate is difficult. Wilson[5] suggests that in doubtful cases an upright plate of the abdomen and search for pneumoperitoneum may assist in diagnosis, but that, if doubt still remains, laparotomy is in order. Wright and co-workers[6] describe the procedure now employed at the Harlem Hospital in questioned perforations. An incision is made down to the peritoneum near the entry wound. Then, by peeling away this layer from the overlying fascia in the region of the wound, absence of penetration will be made evident without actually invading the peritoneal cavity. This, however, is still a major procedure.

The number of times that laparotomies performed for bullet or stab wounds reveal no peritoneal perforation is impressive. Taylor[7] reported 13.8 per cent of negative explorations for gunshot wounds at the Indianapolis City Hospital. Wright found that of 153 cases of stab wound with exploration carried down to or through the peritoneum, 10.8 per cent showed no perforation. In the past three years at the Louisville City Hospital, of 114 operations for gunshot or stab wounds of the abdomen, 24, or 21 per cent, were found not to penetrate the peritoneum. It will be seen in Table I that the percentage of negative explorations was even higher (31 per cent) for stab wounds. Analysis of the 24 negative exploratory laparotomies revealed, furthermore, that in all but 1 the peritoneal perforation, if present, could have been visualized by the peritoneoscope.

TABLE I

114 LAPAROTOMIES FOR GUNSHOT AND STAB WOUNDS AT THE LOUISVILLE CITY HOSPITAL, JULY, 1936, TO JULY, 1939

	GUNSHOT	STAB	COMBINED
Penetrating	49	42	91
Nonpenetrating (preventable laparotomies)	4 (7.5%)	19 (31%)	23* (20%)

*There were actually 24 negative explorations. However, in 1 of these the wound site (a stab in the back) would have been inaccessible to peritoneoscopy.

Since February, 1939, we have employed peritoneoscopy to ascertain in these borderline cases whether or not knife or bullet has penetrated

Received for publication, November 1st, 1939.

CASE REPORTS

CASE 1.—I. H., a 27-year-old colored male, was admitted Feb. 22, 1939. He had been stabbed in the left abdomen one and one-half hours before entry. He denied abdominal pain or hematemesis. On examination he was found to be in good condition, with pulse of 100 and blood pressure of 130/80. The abdomen revealed no spasm or evidence of free fluid. A stab wound was found in the left anterior axillary line 1 inch above the umbilicus. It was 2 cm. in length and surrounded by hematoma. The urine was free of blood. Under local anesthesia the stab wound was excised and peritoneoscopy performed. The peritoneum for

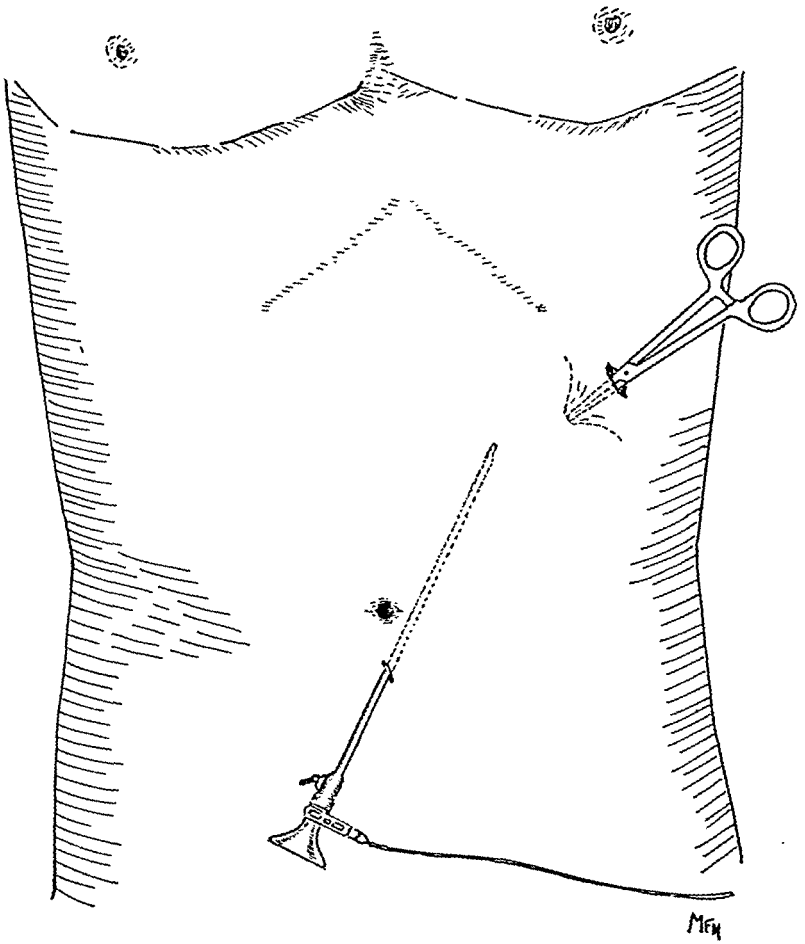


Fig. 2.—Illustration of method of localizing suspected region by indenting peritoneum through débrided entry wound.

a wide area underlying the stab wound was visualized and found to be intact. The patient was able to leave the hospital on the second day following instrumentation.

Comment.—This was a borderline case. Although penetration into the abdominal cavity was unlikely, heretofore laparotomy would have been obligatory to rule it out.

The procedure, using our homemade setup, is essentially the same as that described by Ruddock[11] for his special scope, and for details the reader is referred to his article.

1. After local novocain infiltration, a small stab wound is made down to the transversalis fascia at any spot chosen, but usually in the midline just below the umbilicus.

2. While the patient tenses his abdominal wall, a blunt lumbar puncture needle is cautiously pushed into the peritoneal cavity and through it the abdomen is slowly distended with air.

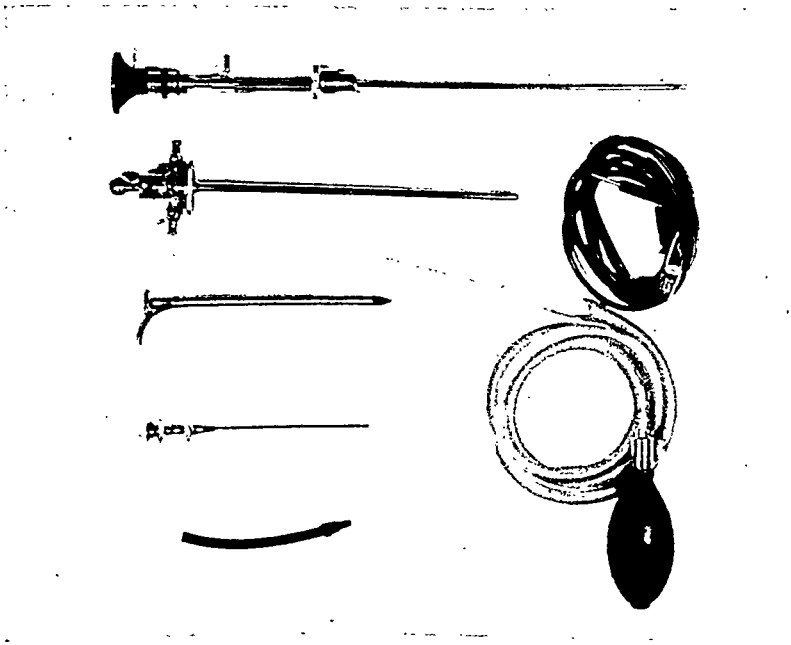


Fig. 1.—Foroblique cystoscope and accessories used in peritoneoscopy.

3. Through the same stab wound, penetration is then safely completed by the trocar which is of the same size as the cystoscope sheath. Upon its withdrawal the scope is immediately inserted. Additional air as needed is injected through the turncock. It will be found that the cystoscope is sufficiently airtight for this.

4. The most important step of the procedure is illustrated in Fig. 2. After the cystoscope has been introduced, a Kelly hemostat is gently poked into the débrided entry wound so as to indent the underlying peritoneum. This localizes the area suspected of perforation. This maneuver, combined with appropriate tilting of the subject to gravitate the viscera, will often allow adequate visualization of regions otherwise inaccessible to the scope. Hemoperitoneum, except when obviously due to instrumentation, is in itself proof of penetration.

anesthesia. No visceral injuries were found. The postoperative course was uneventful and the patient was discharged on the fifteenth postoperative day.

Comment.—This patient had no signs or symptoms of abdominal penetration. The simple procedure of peritoneoscopy disclosed the perforation and settled any doubts as to the indications for exploration.

CASE 5.—W. H., a 36-year-old colored male, was admitted June 21, 1939. About an hour before admission this man had been stabbed in the lower midchest. External bleeding had been profuse and the patient's clothing was drenched with blood. He denied hematemesis, hemoptysis, or symptoms of hemothorax or cardiac tamponade. Examination revealed a patient in shock with pulse 120 and thready and blood pressure unobtainable. His respirations were normal. A transverse lacerated wound 3 cm. long was found in the sixth interspace 2 cm. to the left of the sternum, not bleeding or sucking. The heart sounds were distant. The venous pressure was 5.5 to 7.5 cm. of water. The abdomen was soft with no spasm, tenderness, or evidence of free fluid. Fluoroscopy gave no evidence of heart or chest injury. The patient was given a transfusion of 500 c.c. of citrated blood and in addition parenteral glucose, so that within one and one-half hours his blood pressure was 160, his pulse 110, and his general condition much improved. Then under local anesthesia the stab wound was carefully débrided and peritoneoscopy carried out. The abdominal air inflation was very cautiously carried out, since the knife blade might have passed through the left anterior costophrenic sinus, and thus have allowed some leakage of air into the left pleural cavity. However, no untoward results were observed. A probe passed through the stab wound could be seen indenting the peritoneum on either side of the falciform ligament, but there was no perforation of the abdominal wall or diaphragm. The patient's postoperative course was uneventful and he was discharged on the fourth day.

Comment.—It was suspected that the abdominal cavity had been penetrated and that there was internal hemorrhage from a lacerated liver and possibly injury to hollow viscera. Peritoneoscopy here obviated a major procedure in a partly exsanguinated patient.

SUMMARY

1. Gunshot or stab wounds suspected of perforating the peritoneal cavity should be explored.

2. The decision whether or not a gunshot or stab wound has perforated is often difficult.

3. A surprisingly large number of laparotomies are performed without finding any perforation.

4. Peritoneoscopy is suggested as a safe and reliable method of determining the presence or absence of perforation in the doubtful cases.

5. Reports are presented of five cases successfully managed in this manner.

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CASE 2.—J. B. was admitted March 11, 1939. This 19-year-old colored male was shot in the left upper abdomen with a pistol twenty minutes before entry. He complained of some soreness in the region of the wound but no definite pain or tenderness and no vomiting. The patient appeared to be in no particular discomfort. His pulse was 100; his blood pressure, 134/76. The bullet entry wound was found just below the ninth left rib 8 cm. from the midline. The exit wound was found just below the twelfth rib in the posterior axillary line. The abdomen was soft and free of tenderness. The urine was grossly and microscopically negative for blood. The patient was given spinal anesthesia and after the bullet wounds had been débrided he was peritoneoscoped. Clear vision of entire region underlying the entry wound precluded peritoneal perforation. On the first two postoperative days his temperature rose to 102 and 101°, respectively, but the chart was flat thereafter and the patient was discharged the fifth postoperative day.

Comment.—In this case abdominal penetration seemed so probable that spinal anesthesia was given in preparation for laparotomy. However, peritoneoscopy rendered the major operation unnecessary. The rather extensive bullet tract and hematoma explain the patient's five postoperative hospital days.

CASE 3.—J. C., a 23-year-old colored male, was admitted March 15, 1939. Thirty minutes before admission the patient had been shot in the upper abdomen with a small caliber revolver. His only complaint was dull aching pain in the epigastrium. He denied hematemesis. The patient was in good condition with pulse of 98 and blood pressure of 140/104. A small bullet entry wound was found just to the left of the midline about the sternoxiphoid junction. No point of exit was found. The abdomen was soft, nontender. No fluid wave was demonstrable and there was no evidence of chest injury or cardiac tamponade. The urine was grossly and microscopically negative for blood. A flat plate of the abdomen showed a small caliber bullet in the right lobe of the liver about 1.5 cm. below the dome. Excision of the bullet wound and peritoneoscopy were carried out under local anesthesia. The telescopic observation was not entirely satisfactory in that many adhesions enveloped the right liver lobe and seemed to be binding it to the under surface of the diaphragm. However, no free blood was seen. The patient was kept in the hospital for ten days because of the bullet wound to the liver. Except for several days of elevated temperature, his course was uneventful.

Comment.—With the point of entry and point of lodgment of the slug in the right liver lobe, injury of any hollow viscus was practically precluded. In this case peritoneoscopy was carried out to ascertain the amount, if any, of intraabdominal bleeding.

CASE 4.—O. S., a 27-year-old negro male, was admitted June 18, 1939, just after having been stabbed in the left abdomen. He denied any abdominal or chest pain, hematemesis, or hematuria. Examination showed that the patient was in no acute distress. His pulse was 80; his blood pressure, 140/70. The abdomen was flat, soft, and free of tenderness. A stab wound 0.8 cm. long and bleeding slightly was found in the left midaxillary line at the level of the tenth rib. The patient was taken to the operating room and the stab wound was excised under local anesthesia. Peritoneoscopy, also under local anesthesia, clearly revealed a perforation at the juncture of diaphragm and lateral abdominal wall underlying the external wound. An exploratory laparotomy was then carried out under spinal

HISTOPATHOLOGY OF OLD ANASTOMOTIC WOUNDS OF THE GASTROINTESTINAL TRACT*

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NUMEROUS workers have described the process of healing of anastomotic wounds of the upper part of the gastrointestinal tract of experimental animals, and two workers, Marchand[7] and Angerer,[1] have described the process of healing in comparatively recent anastomotic wounds in the human being, but no comprehensive attempt has been made to study old anastomotic wounds in man.

Marchand in describing very briefly a six-day-old wound following gastroenterostomy mentioned the adhesion of the serosal surfaces by fibrin, the thick muscle layer on the stomach side of the anastomosis, the partial regeneration of the epithelium, cellular infiltration, and damage to the muscle in the region of the sutures, consisting of swelling of the individual muscle fibers. Glandular remnants were noted deep in the mucosa at the point of juncture of the intestine and the stomach.

Angerer[2] in 1927 described the histologic appearance of tissue from the site of three gastroenterostomies performed two and more years before the death of the patients. On gross examination he noted a bunching up of the gastric mucous membrane which protruded slightly through the anastomotic ring. The epithelium on the stomach side of the anastomosis was normal except for dilated cystic pyloric glands with tortuous gastric foveoli. Lymphocytes were present throughout the mucous membrane. The transition zone from gastric to intestinal mucosa was in places sharply defined and in others the change was gradual and there was an intermingling of intestinal and gastric glands. On the intestinal side the epithelium was rich in goblet cells with deep crypts of Lieberkühn, in the sides and bases of which were Paneth cells. His most remarkable finding was islands of what appeared to be normal gastric mucosa in the midst of the intestinal mucosa. The severed ends of the muscularis were united by scar tissue. The smooth muscle layers ended in whirls bound together by fibrous tissue.

Histologic observations on gastrointestinal anastomoses in the experimental animal have been made by many investigators, among them Barbat, 1899; Gould, 1906; Flint, 1917; Grey, 1918; Sabin, 1920; Webster, 1924; Nemiloff, 1925; and Martzloff and Suckow, 1935. Their

*Abridgment of thesis submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of M.S. in Surgery.

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Received for publication, October 17, 1939.

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On examination of the tissue at the line of anastomosis used in a gastroenterostomy, the manner in which the gastric mucosa rolls through the anastomotic ring onto the intestinal side of the anastomosis is usually noticeable.

After an anastomosis between the stomach and small intestine, there is first a destructive phase during which the injured tissue at the anastomotic site is removed. A regenerative phase follows in which new epithelium from the gastric glands and the crypts of Lieberkühn extends over the defect left by the sloughing of injured mucous membrane. Attempts to make sections of the destructive phase for microscopic examination were difficult and the result may be misleading as the only tissue from the site of recently made anastomoses (those performed a few days previously) which was available for study was necessarily from cases in which death had occurred shortly after the operation. In these cases the two pieces of bowel were held together

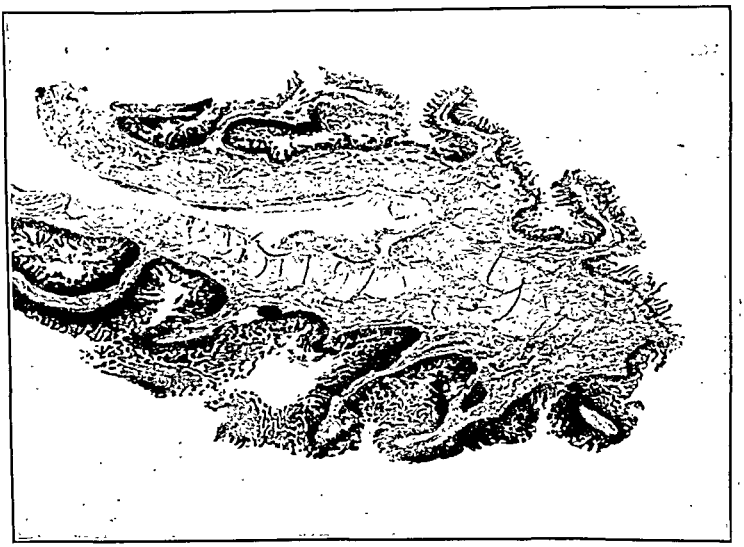


Fig. 1.—Tissue from site of enteroenteric stoma two years old. Patient was 75 years old. Note the infolding and thickening of the wall. (×6.)

largely by suture material and fibrin and were easily pulled apart in cutting the section. The defect between the ends of bowel in such cases was filled with injured mucosa, inflammatory exudate, and regenerating epithelium. Collections of polymorphonuclear leucocytes about the suture material were common. This picture must be somewhat modified in the cases in which recovery ensues. In such instances the regenerative process probably proceeds more rapidly, destruction is not so marked, and the two pieces of intestine are more firmly united than they are in the cases in which death intervenes.

Regenerated epithelium at the point of anastomosis rarely, if ever, was found to resume its preoperative appearance. This was par-

observations gave evidence of (1) destruction and regeneration of the mucosal epithelium, (2) mucosal cysts and suture inclusions, (3) a difference of opinion as to whether there is regeneration of the muscularis mucosae, (4) severe damage to the muscularis propria and a difference of observation as to the extent of regeneration, and (5) extensive pattern of blood vessels in the infolded serosal margin shortly after the operation.

MATERIAL

The gross and microscopic examinations of tissue* from the site of 81 surgical anastomoses of the stomach and upper portion of the small intestine were made. In 8 cases tissue was obtained from the sites of enteroenteric stomas made from one day to five years before death of the patient; in 24 the tissue was from the site of a gastrojejunal stoma of the Polya type made from five days to seven years before death of the patient; in 7 it was from the site of a gastroduodenal stoma of the Billroth I type made from one day to six and one-half years before death of the patient; and in 42, from the site of stomas left after gastroenterostomy performed from eighteen days to twenty-seven years before the death of the patient. Emphasis was placed on the study of old anastomoses; that is, those which had been present for two months or longer at the time of the patient's death. Most of the anastomoses were several years old; the oldest was twenty-seven years.

After examination of each gross specimen, a block of tissue was cut from what was considered a representative portion of the anastomotic ring. Sections 8 μ thick were then cut perpendicular to the line of the anastomosis at three different levels in each block and stained with hematoxylin and eosin. In special cases the Galantha mucin and the van Gieson stains were used.

OBSERVATIONS

The exact site of an anastomosis was not difficult to determine, even on gross examination of a specimen long preserved in formalin.

In the performance of an intestinal anastomosis, serous coat is opposed to serous coat; an infolding of the intestinal wall results which at first is prominent. It later becomes less prominent but persists indefinitely as a slight thickening at the anastomotic ring (Fig. 1). This thickening can be demonstrated by cutting through the intestinal wall in a plane perpendicular to the line of anastomosis and examining the cut section. In such fashion the anastomotic site can be located easily. Fig. 1 reveals this infolding and thickening of the intestinal wall at the anastomotic site two years after an enteroenterostomy.

*A few of the specimens were obtained at necropsy during my association with the Section on Pathologic Anatomy of the Mayo Clinic. Most of them, however, came from the museum of the Mayo Clinic, having been collected over a period of ten years, 1927 to 1937.

jacent to it to be gastric. In some cases, on the gastric side of the anastomosis, at the juncture of intestinal and gastric epithelium glands, not unlike Brunner's glands in appearance, which stained clear and pale with hematoxylin and eosin, were present. The Galantha mucin stain revealed them to contain mucin. Their nuclei were small, smaller than

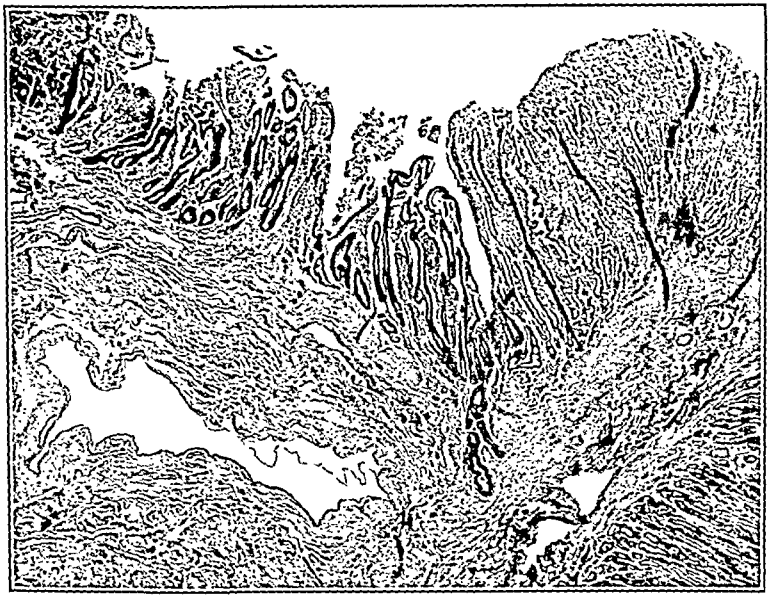


Fig. 3.—Tissue from site of gastrojejunal stoma, forty-five days old. Patient was 46 years old. Note large cyst in musculature of wall and downward extension of mucosal glands at site of anastomosis. (×20.)

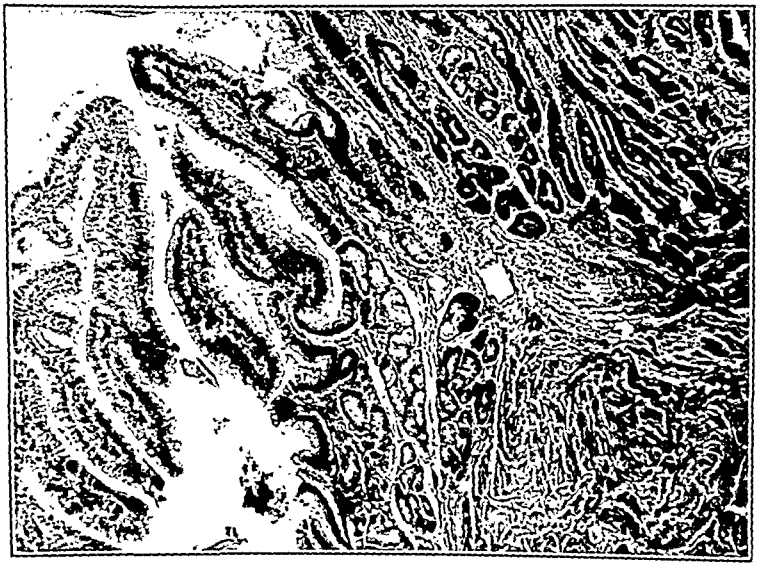


Fig. 4.—Tissue from gastroenteric stoma nine months old. Patient was 40 years of age. Note hyperplastic change in gastric mucosa adjacent to line of anastomosis. (×50.)

ticularly true of the gastric side of a gastrointestinal anastomosis where the condition was suggestive of chronic gastritis. The glands were shallow, their regular arrangement was disturbed, and they rested on connective tissue or muscularis propria rather than on the muscularis mucosae. Cysts were often seen in the gastric mucosa, but they were absent from the intestinal mucosa in the specimens examined.

These cysts were lined with low cuboidal epithelium (Fig. 2). They have been considered to be caused by the downgrowth of epithelium at points where the mucosa was injured at operation either by penetration by suture material or by actual section of the intestinal wall. Such cystic change was fairly common and was not transient. The latter was proved by its presence at the site of the oldest gastroenteric stoma in this series; gastroenterostomy had been performed twenty-seven years before the patient's death. The largest cysts discovered in this study are shown in Fig. 2. In one case (Fig. 3) a large cyst, lying within the musculature of the bowel wall, was observed. Its lining epithelium of low cuboidal cells took the Galantha mucin stain and therefore was proved to be of a mucous secreting type.

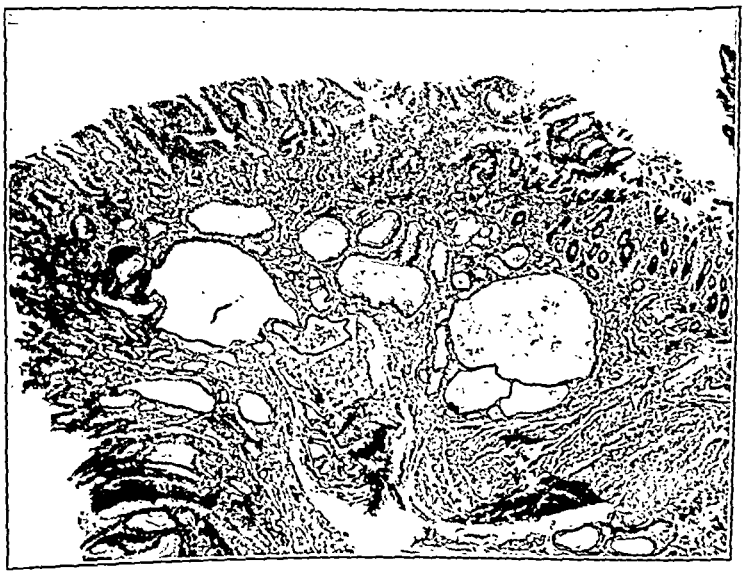


Fig. 2.—Tissue from a gastroenteric stoma twenty-one years old from a man 58 years of age. Note cyst lined with low cuboidal epithelium. (×25.)

Hyperplastic change was noted in the gastric mucosa adjacent to the gastrointestinal stoma in one case (Fig. 4), but there was no evidence of malignant change at the site of any of the anastomoses observed.

In most cases in my series of old gastrointestinal anastomoses the transition from intestinal to gastric epithelium was abrupt so that a specific gland could be said to be definitely intestinal and the one ad-

four months before death and the segments of bowel were united by *almost normal-appearing epithelium and muscularis mucosae.* The muscularis mucosae was a discrete band of tissue which was not fused with the underlying muscle coat or mixed with scar tissue as was usually the case of the anastomotic site. The ends of the muscle coats were separated but connected by a thin layer of scar tissue which lay just beneath and parallel to the muscularis mucosae. As a result of the almost complete absence of muscularis at this point, the thickness of the bowel wall was reduced by more than two-thirds and consisted of mucosa, muscularis mucosae, and a thin layer of scar tissue and muscle covered by serosa. This one case presented the most marked separation of the muscle coats that was noted in any of the cases examined. Yet even with this amount of separation the stoma appeared to have functioned satisfactorily. In a few cases a slight bunching or thickening of the muscularis mucosae was found adjacent to the anastomotic site.



Fig. 5.—Tissue from site of a gastrojejunal stoma of the Polya type. Operation was performed seven years earlier. Patient aged 50 years. Note regeneration of longitudinal muscle and thickened, retracted end of muscularis mucosae. (×25.)

As has been noted by previous observers, the ends of the muscular coats of the intestinal wall were found to be united by a narrow band of scar tissue interspersed with muscle fibers from the muscularis

those of parietal and Paneth cells, were flattened, and lay near the basement membrane. For want of a better name these glands will be referred to as "undifferentiated glands." By starting at the juncture of gastric and intestinal epithelium and working toward the stomach it was possible, in some cases, to demonstrate the gradual appearance of more and more parietal cells in the undifferentiated glands until the undifferentiated glands were replaced by typical gastric glands. The undifferentiated glands probably represented the fundamental mucous gland of the gastrointestinal tract. Their appearance at the anastomotic site is not always transient, for they were observed at the site of one anastomosis which had been made more than four years before death of the patient.

In the intestinal mucosa adjacent to an old gastrointestinal anastomotic site, there was no appreciable change. Paneth cells occurred up to the point of anastomosis and the crypts of Lieberkühn in the tissue differed in no way from those seen farther from the anastomotic site. In anastomotic sites in experimental animals, Sabin found an increase in mucous cells in the crypts of Lieberkühn for as long as fifty to seventy days after operation. No such increase in mucous cells was present in the old anastomoses of this series.

In the gastric mucosa parietal cells occurred up to the point of anastomosis but were present in diminishing numbers in the few gastric glands adjacent to the anastomotic site. In several instances parietal cells were absent in the immediate vicinity of the anastomosis but were present a few millimeters from it.

When the wall of the stomach or small intestine is severed, there is a retraction of the muscularis mucosae, leaving a defect into which the mucosal glands sag or actually grow downward. In two cases examined such a downgrowth of mucosal glands was noted (Fig. 3). Flint said that the muscularis mucosae regenerates in about two weeks and in doing so dips under the mucosal glands and restores them to their proper position. In man this is not always the case. In one case (Fig. 3) in which a gastrojejunostomy had been performed forty-five days before death the downward extension of the mucosal glands at the anastomotic site still persisted.

One of the easiest ways to locate the anastomotic site in examining microscopic slides of old intestinal anastomoses is to follow the muscularis mucosae until a change in its configuration is reached. This change will indicate the anastomotic site. In every case I examined, with one exception, the muscularis mucosae was abnormal or was absent, mixed with connective tissue or fused with the underlying mass of muscle and scar tisue which joined the severed ends of the muscularis propria.

In the one case in which the muscularis mucosae appeared normal at the site of the anastomosis, enteroenterostomy had been performed

of muscularis mucosae rested directly on the mixture of scar tissue and muscle fibers which united the cut ends of the muscularis propria. The mucosa of this, as of most of the anastomotic sites, resembles that seen in cases of chronic gastritis.

COMMENT

When one considers the amount of tissue infolded in the performance of an anastomosis of the gastrointestinal tract, the necessary trauma incident to the completion of such a procedure, the amount of damaged tissue which must be removed and replaced, and the fact that the field is potentially infected, it is remarkable how few changes are found at an old anastomotic site and to how small a region these changes are confined.

Surgeons who perform intestinal anastomoses should keep in mind the fact that there is probably no such thing as union of the severed ends of intestine by primary intention. There is always a destructive phase during which the injured tissue at the anastomotic ring is cast off and regeneration of the epithelium begins. Every effort should be made to minimize the trauma which accompanies the performance of an intestinal anastomosis. During the destructive phase, when the ends of the bowel are joined loosely, it is important that tension on the suture lines, caused by distention of the viscus, be avoided.

SUMMARY AND CONCLUSIONS

Tissue from the site of 81 anastomoses involving the stomach and jejunum of man was studied grossly and microscopically.

At the site of recent anastomoses there is an early destructive phase characterized by the sloughing of injured tissue and the beginning of the process of repair. Collections of polymorphonuclear leucocytes about the suture material are common. At this time, too, union of the cut ends of bowel is fragile and strain on the suture line must be avoided.

In tissue from the site of old anastomoses the anastomotic site can be located easily on gross and microscopic examination.

Cystic changes are present in the gastric mucosa but not in the intestinal mucosa in the anastomotic ring. There is a diminished number of parietal cells in a few gastric glands adjacent to the anastomosis, and glands of undifferentiated or fundamental type are seen at the junction of gastric and intestinal epithelia. The glands extend downward at the site of injury to the muscularis mucosae, and the muscularis mucosae usually is absent or intermingled with scar tissue and muscularis propria. Union of the muscularis propria is by a thin band composed of a mixture of connective tissue and smooth muscle. The vascularity of the anastomotic site is diminished and there is a foreign body type of reaction about suture material.

propria. On this band of scar tissue and muscle the glands of the regenerated mucosa rest. The fibers of the muscularis mucosae were intermingled with, and usually disappeared into, this band of scar tissue and muscle fibers.

As a general rule there was no regeneration of the muscularis propria and its ends were united by scar tissue. In one case (Fig. 5) the longitudinal layer of smooth muscle extended past the anastomotic site, giving the appearance of a regeneration of the longitudinal muscle. Webster noted, after an interval of sixty-eight days, such a regeneration of longitudinal muscle in the experimental animal.

Silk suture material was seen at the site of the anastomosis in several of the cases and, as described by Sabin for the experimental animal, was surrounded by a characteristic foreign body reaction consisting of giant cells and lymphocytes. The oldest anastomosis to show such a reaction was three months old. In recent anastomoses small abscesses surrounding the sutures were common and such an inflammatory reaction rarely persisted for as long as four months.

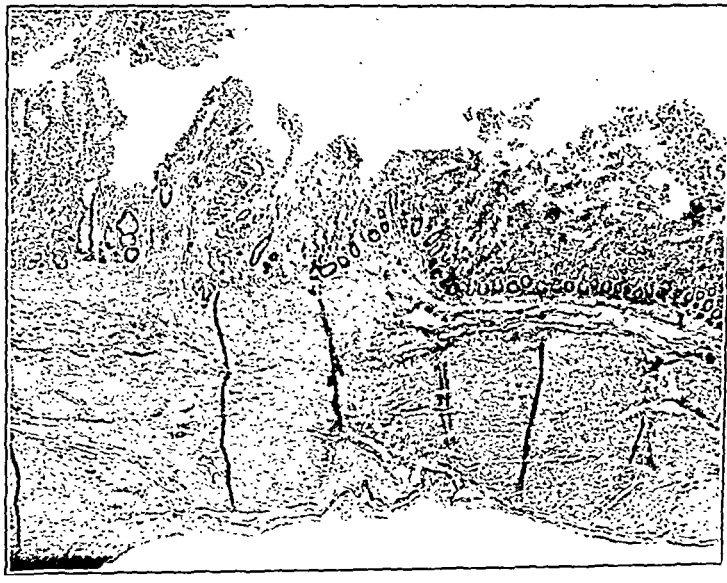


Fig. 6.—Tissue from site of a gastroenteric stoma three months old. Patient was aged 52 years. Tissue at line of anastomosis is most nearly normal of any in series. Note mucosal glands lying directly on band of scar tissue and muscle which unites the severed ends of the muscularis propria. (×25.)

In Fig. 6 an anastomotic site is shown which more closely resembled the bowel before operation than any other observed during this study. Cysts of the mucosa were absent and there was a minimal derangement of the glands, but the amount of connective tissue in the mucosa was increased and the vascularity of the segment of bowel diminished. The mucosal glands were decreased in number and because of the absence

SYNDACTYLISM WITH ABSENCE OF THE PECTORALIS MAJOR

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IN A group of patients with syndactylism the somewhat surprising added anomaly of absence of the pectoralis major was noted several times. It was considered that the defect possibly might be one of atavism from the recognition that the hand mechanism extends up through the shoulder joint, and that an interference with the prehensile qualities in the hand might be expressed also in the shoulder mechanism to cause absence of the pectoral or hugging muscle.[1] This theory was soon known to be wrong, but it is mentioned here as a slight matter of interest.

It was evident that webbed fingers and the absence of the pectoral muscle in the same patient was not a frequent finding, and, on consulting known authorities, it was found that in the patients of Kanavel, Koch, and Mason[2] the same anomalies were observed in one out of thirty-four patients. Although this was found only in a table, with no mention of it in the text, it has been definitely recognized and recorded by these surgeons.

Davis and Germain[3] presented a complete paper on the subject of syndactylism and listed many other concurrent deformities, but they did not include the absence of the pectoralis major. The same is true of a short article by Dorrance and Bransfield.

Christopher[4] has given a very short case report of the double anomaly, but it has probably been overlooked because only the absence of the pectoral muscle was put in the title.

From the rather limited literature on the subject, it appears conclusive that accidents to the limb-bud formation account for the deformities. A summary of the findings in the patients of Kanavel, Koch, and Mason is that all congenital malformations of the hand are thought to be disorientations of the growth of the limb bud, not sufficient to cause destruction, but not an atavism to an amphibian type. Amniotic bands, any reversion to type, and, in fact, all other suggested etiologic factors are eliminated except impairment of germinal cells.

The combination of pectoral absence and syndactylism has been mentioned in several case reports in the foreign literature, but only one paper has been found with the anomaly mentioned in the title, Bierens de Haan.[20] Bing[21] reported the presence of syndactylism in fourteen out of 102 patients with pectoral absence, and Pol[15] collected twenty such patients. There have been two pictures published of patients with pectoral defects and webbed fingers.[22, 23]

Received for publication, October 9, 1939.

When the amount of trauma necessary to the completion of an anastomosis is considered, it is remarkable how few are the changes at an old anastomotic site and to how small a region these changes are confined.

Dr. H. E. Robertson gave me many invaluable suggestions and much advice during this study which I deeply appreciate.

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external abdominal oblique, latissimus dorsi, and intercostales together with deformity of the breast and subcutaneous fat of the chest wall.

There have been several theories advanced as to the etiology of pectoral defects; the most quoted explanation is that of Lewis. He found that in the 9 mm. human embryo the pectoral muscle mass is largely above the first rib. In the 11 mm. embryo it extends lower, but it is still undifferentiated into its component parts and is not attached to the ribs or humerus. In the 16 mm. embryo the clavicular portion is split off and the remainder then divides into the sternal portion and the pectoralis minor. Perhaps the failure of the primitive mass to attach itself to the ribs and sternum might allow its not becoming differentiated into its normal component parts. This coincides with the known fact that the defects are usually in the caudal portion.

It is also known that the pectoralis major develops from the fifth, sixth, seventh, and eighth central myotomes. This suggests that some developmental accident occurring in the seventh and eighth myotomes might result in the syndrome of absence of the lower portion of the pectoralis major and the entire pectoralis minor, together with deformity of the hand.

The patient shown in Fig. 1 is a good example of the typical deformity of absent pectoral and syndactylism and may have absence of the clavicular head of the muscle as well. There is also some degree of reduction of size of the forearm and hand. The patient shown in Fig. 2 had a fascial band slightly limiting the motion of the arm and this was excised at the time of operation on the hand.

Neither of these patients has any subjective or objective impairment of movement or function. Four other patients with the same anomalies have been seen, but the incidence has not been determined in the entire series of webbed fingers that have been operated upon.

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More than 300 patients with congenital absence of part or all of the pectoral muscle group have been reported, but the true incidence of the lesion is unknown as the deformity is often not obvious and is discovered only by careful examination of the shoulder area. The lesion is usually not disabling and frequently has not been discovered by the patient or his family. One case has been noted of a pectoral absence on the right in a right-handed professional fencer.

Complete absence of the pectoralis major is rare, absence of the sternocostal portion with or without absence of the pectoralis minor being the usual lesion. Clinically these patients present an absence of the normal, well-developed, curved, anterior axillary fold. (Fig. 1.) A few patients have a band of scar tissue forming a web over the anterior surface of the axilla, and this may limit abduction of the arm. (Fig. 2.) There has been only one bilateral case reported and only one instance in which the deformity was hereditary.[12]

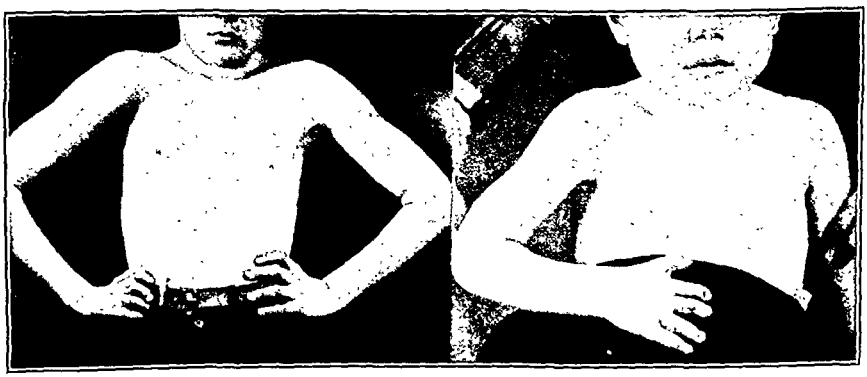


Fig. 1. Fig. 2.

Fig. 1.—Absence of pectoralis major and syndactylism, right.
Fig. 2.—Replacement of pectoralis major with a fibrous band which was excised at the time of operation on the webbed fingers.

Associated congenital anomalies of the homolateral hemithorax and upper extremity are quite common. About one-fourth of the patients have rib or costal cartilage defects[13] and about one-third of the women have breast defects. The rib and costal cartilage defects have in some instances been so extensive as to produce a visible mass by herniation of the lung. Sprengel's deformity is occasionally associated with absence of the muscle. In 171 cases of pectoral deficiency collected by Bing and Gundlach, cited by Laan,[13] there was shortening of the upper extremity in thirty-three cases and there were deformities of the hand in twenty-seven cases. The hand anomalies seen were syndactylism, brachydactylism, absence of the metacarpals, and one case of "intra-uterine amputation" of the hand. In Polland's case, cited by Pol,[15] there was associated absence of the pectoralis major and external abdominal oblique with syndactylism. In Furst's[16] case there was total absence of the pectoralis major and minor, partial absence of the serratus anterior,

completely ignore, them. With some effort on the part of the examiner, however, a history of nocturia, frequency or difficulty in urination can usually be obtained.

Physical Examination.—Tenderness over the affected kidney or ureter is the common finding on physical examination. In view of the incipient nature of the urinary obstruction, rectal examination does not ordinarily disclose any marked degree of prostatic enlargement.

Urological Investigation.—Upon cystoscopic examination, an early form of encroachment on the vesical neck is to be anticipated. It should be noted that in all of the cases of this series there was some involvement of the posterior commissure, either in the form of a median bar, a median lobe, or a contracture of the vesical neck.

The bladder shows the changes of early hypertrophy which constitute its response to obstruction. This changed physiologic state is reflected in a decreased capacity and a small amount of residual urine. There is trigonal hypertrophy (secondary to a posterior commissural obstruction, as discussed later) and trabeculation of the vesical wall (evidence of hypertrophy of the detrusor). Large amounts of residual urine and the presence of cellules and diverticula are manifestations of a later stage of obstruction and are not commonly seen in this syndrome.

The interureteral ridge may be sufficiently hypertrophied to form a well defined bas-fond. The ureteral orifices are lengthened and slit-like, often appearing as very fine, barely perceptible lines (Fig. 1*A* and *B*). In some instances free motility of the orifice is absent and urine is seen to escape from the affected ureter in a stream entirely lacking in projectile force. This phenomenon was carefully observed in some of our patients following the administration of indigo carmine intravenously.

In no instance was there cystoscopic evidence of cystitis or of inflammatory reaction surrounding the ureteral orifices which might have accounted for ureteral obstruction. Even in the two cases in which the urine obtained from the bladder was found to contain pus cells and organisms, the infection was so mild that no gross inflammatory change was discernible.

Upon attempting to catheterize the affected ureters, considerable difficulty is encountered in mounting the intramural portion. A No. 6 ureteral catheter cannot be forced through this region, as a rule, unless it is made rigid with a wire stylet. In one instance, however, it was possible to force a No. 8 olive-tipped catheter through the obstructed area; whereas the more pliable smaller size could not be introduced. In another case, in which a ureteral calculus was suspected, it was found that spinal anesthesia produced sufficient relaxation to permit catheterization with a No. 6 catheter, which previously had been found impossible. When the intramural portion of the ureter has been passed, a steady flow of urine often escapes from the catheter, indicating a

RENAL COLIC CAUSED BY EARLY OBSTRUCTION OF THE LOWER URINARY TRACT

With a Report of 9 Cases

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DILATATION of the upper urinary tract is observed frequently in the presence of prolonged obstruction of the lower urinary tract. Although this type of hydronephrosis and hydroureter is usually painless at its inception, we have come to recognize a small group of patients who, during the early stages, experience colic.

In these cases symptoms referable to the kidney or ureter are so predominant that attention is likely to be diverted from the underlying abnormality. The clinical importance of recognizing the true etiological factor is obvious. It is our purpose, therefore, to describe this syndrome and to discuss the pathologic mechanism of its production.

We have observed nine patients who experienced pain referable to the kidney or ureter which could be explained only on the basis of early obstruction of the lower tract. In every instance a careful urological investigation revealed some type of obstruction of the vesical neck and pointed to a narrowing of the intramural portion of the ureter. The salient features of these nine cases are summarized in Table I.

CLINICAL ASPECTS

Symptoms.—It will be noted that the pain experienced is usually typical of renal colic. Although it may arise in the region of the kidney, the ureter, or the external genitals, all of these areas are likely to become involved in its final radiation. Occasionally the pain is induced by the act of urination, but for the most part there is no relationship to voiding. A dull, aching renal or ureteral pain is less common than colic. The right and left sides are involved with equal frequency. Bilateral pain has not been observed. Although most of the patients of this series were seen in their first seizure, in a few instances recurrent attacks had occurred and one patient complained of intermittent aching pain in the left iliac fossa of seven years' duration.

Careful questioning is required in order to elicit symptoms of obstruction of the lower urinary tract. These symptoms are so much less dramatic than colic that patients are prone to minimize, if not

Received for publication, October 13, 1939.

TABLE

SUMMARY

CASE NO.	SEX AGE	SYMPTOMS	PHYSICAL EXAMINATION	LABORATORY DATA	CYSTOSCOPIC	
					LOWER TRACT	MIDTRACT
1	55 M	Excruciating pain in right lumbar region for 24 hr.; no association with urination Past history: nocturia, frequency and hesitancy for 1 yr.	Suffering from severe pain and tenderness over right kidney Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms; P.S.P.* normal	Median fibroglandular bar	R.U.,† 25 c.c.; B.C.,‡ 300 c.c.; trabeculation of bladder; hypertrophy of trigone; urine lazes from taut right orifice
2	36 M	Severe pain in right iliac fossa for 24 hr.; started when patient attempted to void Past history: frequency and hesitancy of urination for 2 mo.	Tenderness over right kidney and ureter Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Contracture of vesical neck	R.U., 40 c.c.; B.C., 250 c.c.; early trabeculation of bladder; hypertrophy of trigone; urine lazes from right orifice
3	63 M	Attacks of severe right lumbar pain associated with increasing difficulty of urination for 2 yr.; pain radiates to inguinal region and right testicle	No tenderness over either kidney Rectal examination: prostate enlarged to 1½ times normal size	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Median lobe prostatic hypertrophy	R.U., 75 c.c.; B.C., 450 c.c.; trabeculation of bladder; hypertrophy of trigone (Fig. 1*A*)
4	75 M	Severe left lumbar pain, radiating to inguinal region and penis, of 2 days' duration Past history: small urinary stream for 1 yr.	Tenderness over left kidney Rectal examination: prostate enlarged to 3 times normal size	Urine: many W.B.C. and motile rods P.S.P. normal	Trilobed prostatic hypertrophy; small intravesical median lobe, large intraurethral lateral lobes	R.U., 60 c.c.; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone (Fig. 1*B*)
5	49 M	Excruciating pain over left kidney, gradually subsiding over 3-day period Past history: nocturia up to 3 times and small urinary stream for 3 yr.	Tenderness over left kidney Rectal examination: prostate slightly enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Fibrous median bar	R.U., 50 c.c.; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone; taut orifices

*P.S.P., Total phenolsulphonephthalein renal function test.

†*R.U.*, Residual urine.

‡*B.C.*, Bladder capacity.

§*K.U.B.*, Plain x-ray of kidneys, ureters, and bladder.

I

OF CASES

FINDINGS				
UPPER TRACT	X-RAY FINDINGS	TREATMENT	PATHOLOGIC REPORT	RESULT AND FOLLOW-UP
Extremely difficult to mount intramural portion of right ureter; relief of pain upon passing catheter; good function, no infection, either kidney	K.U.B.§ negative; pyeloureterogram normal (Fig. 2*A*)	Transurethral prostatic resection; right ureteral meatotomy	Prostatic tissue showing chronic inflammation	2 mo.: patient asymptomatic; R.U., 0 Cystoscopy: site of resection and meatotomy well healed; ureter easily catheterized; trigonal hypertrophy and trabeculations less marked
Stylet required in mounting intramural portion of right ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram negative	Transurethral resection of vesical neck; right ureteral meatotomy	Fibromuscular tissue	2½ yr.: R.U., 0 Has had no recurrence of pain or urinary symptoms since operation; ureter easily catheterized
Slight difficulty in mounting intramural portion of ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram normal; pain reproduced on right Cystogram: no reflux	Transurethral prostatic resection	Benign prostatic hypertrophy, chronic prostatitis	3 yr.: Well; R.U., 0; B.C., 500 c.c.; no urinary symptoms or recurrence of pain Urine: No W.B.C., R.B.C., or organisms; ureter presents no obstruction to No. 10 bulb catheter (see Fig. 1 [*A'*, *A"*])
Stylet required in mounting intramural portion of left ureter; good function, no infection, either kidney	K.U.B. negative; bilateral pyeloureterogram normal (Fig. 2*B*) Cystogram: no reflux	Conservative perineal prostatectomy	Benign prostatic hypertrophy, chronic prostatitis	2 yr., 8 mo.: well; R.U., 0; B.C., 550 c.c.; no urinary symptoms or recurrence of pain Urine: no W.B.C., R.B.C., or organisms; Ureter presents no obstruction to No. 10 bulb catheter (see Fig. 1 [*B'*, *B"*])
Marked difficulty in mounting intramural portion of left ureter; no infection in left kidney	K.U.B. negative; left pyeloureterogram, mild dilatation of left ureter (Fig. 2*C*)	Transurethral prostatic resection	Fibromuscular hypertrophy of prostate	1 mo.: patient asymptomatic; R.U., 0; B.C., 400 c.c. Urine: Many W.B.C. and bacilli

TABLE I

CASE NO.	SEX AGE	SYMPTOMS	PHYSICAL EXAMINATION	LABORATORY DATA	CYSTOSCOPIC	
					LOWER TRACT	MIDTRACT
6	61 M	Intermittent aching pain in left iliac fossa for 7 yr.; worse when straining to void Past history: difficult urination for 8 yr.	Tenderness over left ureter Rectal examination: prostate slightly enlarged	Urine: many W.B.C. and bacteria P.S.P. normal	Median lobe prostatic hypertrophy	R.U., 100 c.c.; B.C., 300 c.c.; trabeculation of bladder and a few cellules; hypertrophy of trigone; orifices fine and taut
7	62 M	Attacks of pain over right kidney for 1 yr.; radiation to iliac fossa and right side of scrotum Past history: increasing difficulty of urination for 2 yr.	No tenderness over kidney or ureter Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Median fibroglandular bar	R.U., 0; B.C., 300 c.c.; trabeculation of bladder; hypertrophy of trigone; urine ejected from orifice with poor force
8	55 M	Severe pain in right iliac fossa, radiating to right lumbar region and right testicle in 5-hr. period; nausea and vomiting Past history nocturia and small urinary stream for 1 yr.	Tenderness over right kidney Rectal examination: prostate slightly enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Broad median bar; slight intraurethral enlargement of lateral lobes of prostate	R.U., 150 c.c.; B.C., 400 c.c.; trabeculation of bladder and early cellule formation; hypertrophy of trigone; taut orifices
9	62 M	Recurrent attacks of pain over left kidney for 2 wk. Past history: nocturia and frequency of urination for 1 yr.	No renal tenderness Rectal examination: prostate not enlarged	Urine: no W.B.C., R.B.C., or organisms P.S.P. normal	Small median bar	R.U., 30 c.c.; B.C., 400 c.c.; hypertrophy of trigone; no trabeculation of bladder

retention of urine in the ureter. During colic this maneuver brings about immediate relief from pain. In one case mounting the intramural portion of the ureter reproduced the patient's pain, and in another distention of the upper tract with skiodan preliminary to taking a pyeloureterogram produced this result.

A plain roentgenogram is an important step in furnishing presumptive evidence in eliminating a ureteral calculus as a cause for the pain. Pyeloureterograms reveal a grossly normal kidney and ureter in most instances, although the early changes of obstruction are occasionally demonstrable in the ureter (Fig. 2). A bilateral dilatation of the ureters was found in one case, although pain had occurred only on one side. A slight unilateral dilatation of the involved ureter was observed in another case and a lengthening of the affected ureter in a third. A clearly demonstrable hydronephrosis was not seen in this series.

—CONT'D

FINDINGS UPPER TRACT	X-RAY FINDINGS	TREATMENT	PATHOLOGIC REPORT	RESULT AND FOLLOW-UP
Moderate difficulty in mounting intramural portion of left ureter; no infection in left kidney	K.U.B. negative; left pyeloureterogram, normal Cystogram: no reflux	Transurethral prostatic resection	Benign prostatic hypertrophy, chronic prostatitis	3 mo.: died on readmission to hospital Diagnosis at necropsy: cirrhosis of liver; no recurrence of pain; frequency of urination and nocturia persisted Urine: many W.B.C., R.B.C., and organisms
Passing No. 8 ureteral catheter up right ureter reproduced pain; good function, no infection, either kidney	K.U.B. negative; intravenous urography normal	Advised to undergo transurethral prostatic resection, but patient refused treatment		6 mo.: patient writes that he still suffers from attacks of right lumbar pain
No difficulty in introducing No. 6 catheter to either renal pelvis, no infection, good function, either kidney	K.U.B. negative; bilateral pyeloureterogram, both ureters dilated; no hydronephrosis	Transurethral prostatic resection	Benign prostatic hypertrophy	4 mo.: patient asymptomatic; no recurrence of pain, R.U., 0 Urine: many W.B.C. and organisms Cystoscopy: trigone much less prominent; trabeculations still present, though fading
Extreme difficulty in mounting intramural portion of left ureter; finally possible with filiform-tipped catheter under spinal anesthesia; good function, no infection either kidney	K.U.B. negative; bilateral pyeloureterogram, lengthening and mild dilatation of left ureter (Fig. 2 *D*)	Patient to undergo transurethral prostatic resection		

Laboratory Tests.—Total and differential tests of renal function made with phenolsulphonephthalein failed to demonstrate any impairment, and specimens of urine obtained from the kidneys yielded no evidence of renal infection by smear or culture.

Diagnosis.—There is nothing distinctive in the type of pain experienced in this syndrome. The diagnosis can be made only on the basis of the urological investigation. The most frequent problem in differential diagnosis is the ruling out of a ureteral calculus which has become obstructed in the intramural portion of the ureter. When such a calculus is not of sufficient size or density to cast a roentgenographic shadow and does not cause bulging of the overlying vesical mucous membrane, the passage of a wax bulb may aid in its detection. Other conditions, such as a ureteral stricture, for example, rarely give rise to confusion.

Treatment and Result.—Removal of the obstruction of the lower urinary tract was found to afford complete relief from pain in all of our patients who underwent treatment. In no instance was there a recurrence following operation, in spite of the fact that some of the patients had suffered from pain for several years. Although the ureteral dilatation which was carried out as a part of the original investigation

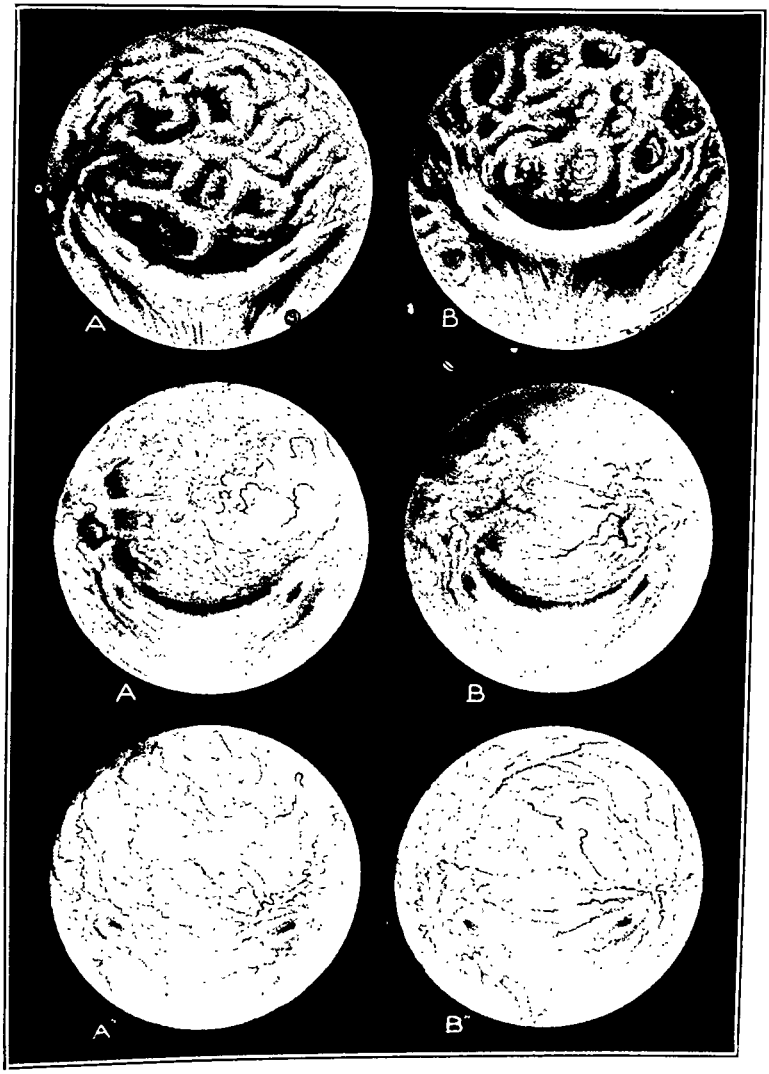


Fig. 1.—Cystoscopic view of the trigone and fundus of the bladder in Cases 3*A* and 4*B*. *A* and *B*, Prior to treatment. Note the pronounced trigonal hypertrophy with the formation of a bas-fond. The ureteral orifices appear as fine, barely perceptible lines. Trabeculations are prominent. *A'* and *B'*, Six months following operation. The trigone has become less prominent and the ureteral orifices appear more relaxed. The trabeculations are fading. *A''* and *B''*, Two years after operation. The trigone and ureteral orifices have resumed their normal appearance. Trabeculations can no longer be seen and there is no further suggestion of a bas-fond.

may have yielded temporary relief, the prolonged freedom from pain, extending up to two and three years, must be attributed to the removal of the primary obstructing factor.

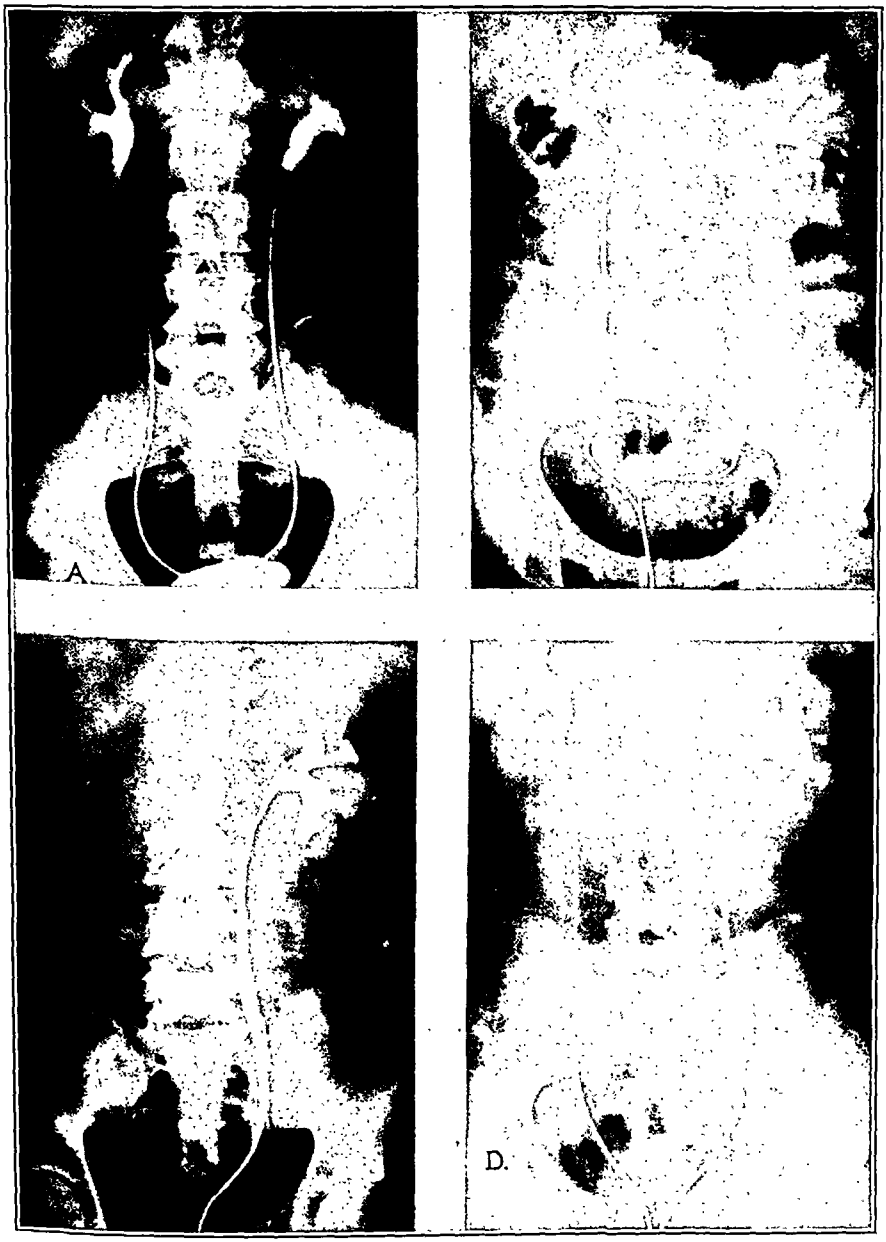


Fig. 2.—Typical pyeloureterograms made at the time of the initial examination. *A*, Case 1. Right renal colic for twenty-four hours. No dilatation of ureter or renal pelvis. *B*, Case 4. Left renal colic for forty-eight hours. No dilatation of ureter or renal pelvis. *C*, Case 5. Left renal colic for three days. Mild dilatation of the ureter above the intramural portion. Note that no skiodan has flowed into the bladder around the catheter. *D*, Case 9. Recurrent attacks of left renal colic for two weeks. Lengthening of the ureter and mild dilatation above the intramural portion.

We now consider ureteral meatotomy, a procedure which we performed for two of our early patients, as a superfluous step which may be fraught with danger. There is the possibility that the edema produced by the meatotomy may cause a temporary occlusion of the ureter and lead to an ascending renal infection. In addition, a too extensive meatotomy may predispose to a vesicoureteral reflux. We also believe that it is inexpedient to resect the interureteral ridge, except in those rare instances in which this structure itself produces an obstruction to the vesical neck.

Immediately after operation, if the removal of the obstruction has been complete, the residual urine will be found to be eliminated and within a period of a few weeks the capacity of the bladder will have returned to normal. As early as a few months following operation we were able to detect, on cystoscopic examination, a recession in the pathophysiologic changes of the bladder and ureter (Fig. 1 *A'* and *B'*). After a still longer period a complete return to normal was observed (Fig. 1 *A''* and *B''*). There was gradual fading and final disappearance of the trabeculations of the bladder. The trigone became less and less prominent as time elapsed. The ureteral orifices lost their taut, stretched-out appearance, became relaxed, and exhibited a normal mobility during the ejection of free spurts of urine. Catheterization of the intramural portion of the ureters offered no further difficulty.

DISCUSSION

In reviewing this series of cases, it will be noted that the common findings were: (1) an early form of obstruction of the vesical neck involving the posterior commissure, (2) hypertrophy of the trigonal and detrusor muscles of the bladder, (3) narrowing of the intramural portion of the affected ureter, and (4) little evidence of functional or anatomical change in the upper urinary tract, although pain referable to the kidney or ureter was the outstanding symptom in every case.

These patients present, therefore, the early stages of a physiologic response on the part of the bladder, the ureter, and the kidney to an obstruction of the lower urinary tract. This occurs during a period before the permanent changes of muscular atrophy and replacement by connective tissue have left their indelible traces in the form of vesical diverticulum, hydroureter, and hydronephrosis. The primary lesion is some form of obstruction of the posterior commissure, the secondary lesion a compression of the intramural portion of the ureter, and the remote effect a distention of the ureter and renal pelvis which gives rise to pain.

It is well known that during mechanical obstructions of the ureter colic occurs only if the renal pelvis or the ureter is suddenly distended. Complete obstruction, of course, is not a prerequisite for pain; a partial narrowing is sufficient to produce sudden distention. As a matter of fact, it is doubtful that complete obstruction of the ureter ever occurs

in uncomplicated obstructions of the vesical neck except for transient intervals. Even in the most advanced cases, urine continues to enter the bladder from the hydronephrotic kidney. That the hydronephrosis and hydroureter arising from an obstruction of the lower urinary tract are so often painless in their development may be attributed to the more common gradual distention, as opposed to sudden distention. Should treatment be delayed in patients who complain of early pain from this source, periodic recurrences may continue, as in two cases of this series; or, following the prodromal seizure, many will develop marked degrees of dilatation of the upper urinary tract without experiencing further pain. Recurrent pain is more likely to be associated with an intermittent obstruction, a recession of pain with a steadily progressive obstruction.

Although there is some divergence of opinion as concerns the exact nature of the ureteral disturbance, most investigators concur in localizing the change to the intramural portion, a contention which is supported by our clinical observations. Examination of the lower portion of the ureter in a specimen which displays advanced hydroureter secondary to prostatic hypertrophy will bear out this view. It will be seen that the widely dilated ureter abruptly gives way to the narrowed intramural segment at the point where it enters the wall of the bladder (Fig. 3).

The narrowing of the intramural portion of the ureter has been variously ascribed to the following factors: (1) hypertrophy of the trigone, (2) hypertrophy of the detrusor, (3) an elevation of the intravesical pressure, and (4) an increased irritability of the vesical and ureteral musculature. A compression of the ureter by the vas deferens, should this latter structure be displaced, in pronounced enlargements of the prostate, need not be considered in these early obstructions.

Tandler and Zuckerkandl observed a close involvement of the lower ends of the ureters in hypertrophy of the trigone, which they readily explained by the connection of the ureteral and trigonal musculature. They found that, in trigonal hypertrophy, the interureteral ridge withstands expansion and maintains the normal distance between the ureteral orifices. This unyielding quality of the intraureteral ridge has a tendency to draw the intramural portion of the ureter into the cavity of the bladder, thereby producing lengthening and narrowing of that segment, as well as a change in its form and obliquity (Fig. 3).

Frontz and Landes first called attention to the association between trigonal hypertrophy and those obstructions of the vesical neck which involve the posterior commissure.* They noted that, although the detrusor undergoes hypertrophy in pure hyperplasia of the lateral lobes, the trigone remains unchanged. They did not consider the pos-

*Frontz and Landes presented these observations as confirmation of the truth of Young's explanation of micturition, that by its contraction the trigone pulls open the floor of the internal sphincter.

sibility that an obstruction of the ureter might have been caused by trigonal hypertrophy, but in our series this was a constant finding. Trigonal hypertrophy was observed in all of our patients and it was invariably secondary to some form of obstruction at the posterior commissure.

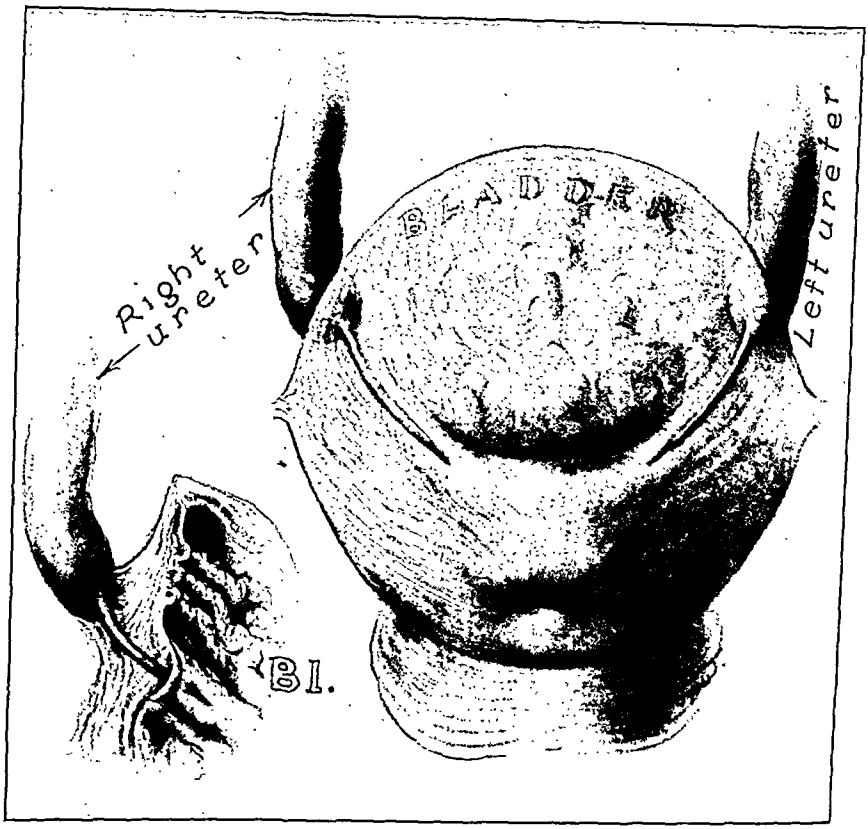


Fig. 3.—Changes in the lower portion of the ureter secondary to marked prostatic hypertrophy. Specimen obtained at necropsy and cleared by Spalteholz technique following injection of ureters with a gelatin suspension of India ink. Note that the widely dilated ureter becomes abruptly constricted at its entrance into the wall of the bladder. There is a lengthening and narrowing of the intramural portion caused, in part, by the marked trigonal hypertrophy which has a tendency to draw the lower portion of the ureter into the cavity of the bladder.

Kretschmer and Hibbs, following a histologic study, concluded that the obstruction of the lower ends of the ureters was caused by hypertrophy of the longitudinal fibers of the muscularis of the ureter. In their opinion these fibers participate in the trigonal hypertrophy which results from obstructive lesions of the vesical neck.

Kreutzmann attributed the difficulty which he encountered in catheterizing the intramural portion of the ureter in cases of prostatic obstruction to hypertrophy of the vesical musculature. Tandler and Zuckerkandl, however, denied that the interlacing fibers of the detrusor ever cause a constriction of the ureter. They felt that the narrowing of

this portion of the ureter is more apparent than real and that, in addition to the changes which they previously described, a compression of the ureter may be accounted for by a valvelike mechanism. As the pressure within the bladder rises, one wall of the intramural portion of the ureter is pressed against the other, even to the extent of producing a flattened "saber-sheath" appearance in long-standing cases.

Hepburn first suggested the possibility of spasm, as a cause of obstruction of the lower end of the ureter, to account for some instances of renal pain. He described this more particularly in bilateral obstructions and especially in the presence of trigonal hypertrophy. Although Hepburn recognized the association between obstruction of the ureter and trigonal hypertrophy, he did not appear to realize the significance of trigonal hypertrophy in obstructions of the vesical neck. Instead, he regarded this spasm as a form of neuromuscular incoordination and consequently treated his patients by ureteral dilatations and division of the interureteral muscle. The relaxation which was obtained under spinal anesthesia in one of our cases, sufficient to permit catheterization of a previously obstructed ureter, is further suggestive evidence of the occurrence of spasticity in some instances.

The infrequent presence of infection of the bladder in our series would seem to exclude inflammation as a primary factor.

Can any explanation other than obstruction of the intramural portion of the ureter be forwarded to account for the renal and ureteral pain in these cases? When colic is initiated by the act of voiding, for example, is there actually a sudden closure of the already narrowed portion of the ureter, as by contraction of the trigone or an increase of the intravesical pressure incident to voiding, or does a vesicoureteral reflux or retroperistalsis of the ureter take place? Although we do not deny that a vesicoureteral reflux occurs under numerous circumstances, we have not observed anything which approaches an abnormal patency of the lower end of the ureter in this early response to obstructions of the vesical neck. A reflux may be observed, certainly, during the late stages of prostatic obstruction when the bladder has become decompensated, as well as in chronic infections of the bladder. In both of these conditions, however, there is a replacement by connective tissue of the vesical and ureteral musculature which predisposes to a reflux as a potential source of pain. Although cystograms in three of our patients gave no evidence of regurgitation, this negative finding does not entirely eliminate the possibility of a reflux, for it is possible that the pressure at which the cystograms were taken did not reduplicate the high intravesical pressure attained spontaneously. Should any type of regurgitation ever take place in this condition, it probably would be in the nature of a retroperistalsis initiated in the irritable muscles of the lower end of the ureter.

We still seek a more exact understanding of the pathologic changes which take place in the intramural portion of the ureter secondary to

obstructions of the lower urinary tract. For such an understanding, it seems necessary first to dispel that confusion which exists concerning its normal anatomy. In spite of the voluminous literature on this subject, we are impressed with the need for a painstaking anatomical study of the relationship between the lower end of the ureter, Waldeyer's sheath, and the trigonal muscle.

SUMMARY AND CONCLUSIONS

Pain which is usually typical of renal colic has been observed in nine cases of early obstruction of the vesical neck. Additional findings were trigonal hypertrophy, early trabeculation of the bladder, difficulty in mounting the intramural portion of the ureter, and little evidence of dilatation of the upper urinary tract.

A study of this problem has led us to conclude that this pain is usually caused by a narrowing of the lower end of the ureter, which results from an obstruction at the posterior commissure. The anatomical relationship between the intramural portion of the ureter, the trigonal muscle, and the detrusor of the bladder is such that hypertrophy of these muscles gives rise to ureteral obstruction. Muscular spasm and an increased intravesical pressure may play important contributing roles, although infection is not a necessary counterpart. The possibility of a vesicoureteral reflux is considered but dismissed as unlikely in these early cases of obstruction.

The recognition of the true cause of the pain is of paramount importance as concerns the institution of proper treatment before any permanent damage has been done. From this point of view the early occurrence of pain is a fortunate danger signal which should not be disregarded.

Following removal of the primary obstruction, the patient is permanently relieved of any further pain and the vesical and ureteral musculatures gradually return to their normal state, giving evidence, thereby, that these early changes are primarily physiologic in nature.

Since obstructions of the lower urinary tract may occur at any age and in either sex, this syndrome should be kept in mind as a possible cause of pain originating in the upper urinary tract, more especially if there has been some difficulty in urination previous to the onset of the colic.

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Editorials

Peritoneoscopy

ALTHOUGH peritoneoscopy was performed for the first time approximately forty years ago, it did not become a popular procedure until recent years. Ruddock has been largely responsible for the widespread awakening of interest in this subject, and, aided by the development of a modern endoscopic instrument, he has developed this method of diagnosis to its present form. An accurate evaluation of peritoneoscopy may need to await the lapse of further time, although certain current impressions regarding it seem to be evolving as facts. With the initial wave of enthusiasm that followed the revival of this procedure, reports in the literature have emphasized for the most part only its advantages. It would appear that the limitations and contraindications of this procedure should not go without mention.

Peritoneoscopy may be a very useful procedure in selected cases. When accurate diagnosis of chronic intra-abdominal disease, especially that associated with ascites, is difficult or impossible by the use of ordinary methods of clinical investigation, peritoneoscopic inspection of the abdominal cavity may be the means of establishing the diagnosis in a simple manner and beyond doubt. Removal of a significant biopsy specimen through the peritoneoscope, which should always be performed when feasible, affords irrefutable diagnostic evidence. The risk is slight, discomfort to the patient is minimal, and the necessary period of hospitalization is short. Pentothal sodium intravenously administered provides a more pleasant anesthesia for the patient than local infiltration of the abdominal wall with procaine hydrochloride (novocain). The two conditions in which peritoneoscopy may be helpful most frequently are intra-abdominal malignancy and cirrhosis of the liver when these diagnoses cannot be established with certainty by any other method except exploratory laparotomy. Various other lesions may be diagnosed less frequently.

It seems important that the limitations of peritoneoscopy should be appreciated as clearly as its merits. It appears definite that peritoneoscopy will never replace exploratory laparotomy, although in a relatively small, selected group of cases it may render operation unnecessary. Great significance usually cannot be attached to findings of negative significance on peritoneoscopic examination, as obviously only the surface of certain intra-abdominal viscera can be visualized and even the surface of many structures cannot be seen. In this regard, peritoneoscopy is similar to bronchoscopy and is in contrast with cystoscopy.

In the case of bronchoscopy, only a very limited portion of the pulmonary system can be visualized with the result that this examination can exclude disease with certainty in only a limited region. Only when an organic lesion is grossly evident within the abdominal cavity can peritoneoscopy be expected to establish an accurate diagnosis.

It has been stated that peritoneoscopy may be employed to determine the operability of certain malignant lesions; for example, carcinoma of the stomach. If, in these cases, the decision as to operability is based on the presence of metastatic lesions, this practice may be sound; however, when this decision is based solely on the local extent of the primary lesion, the use of peritoneoscopy for this purpose seems definitely unwise. One need not operate many times for gastric carcinoma in order to appreciate how difficult a decision in regard to operability may be, even when the abdomen is open and the lesion is in the surgeon's hand. Even large, high-lying lesions which have invaded the gastrohepatic or gastrocolic omentum may be completely removed at times with a reasonable hope of cure. In contrast, certain smaller lesions which have penetrated into the pancreas are actually inoperable. This fact could not possibly be detected by means of the peritoneoscope. Any method which is accepted as capable of supplying criteria in regard to the operability or inoperability of malignant lesions should be as infallible as is possible, for an operable lesion which is erroneously considered to be inoperable may be responsible for a direct loss of life. It appears probable that the experienced roentgenologist is able to offer as accurate an opinion as, or even a more accurate opinion than, the peritoneoscopist regarding the operability of gastric carcinoma, based on the local extent of the lesion, and it is well known that the roentgenologist may occasionally be in error in this regard.

The use of peritoneoscopy in the presence of possible acute inflammatory conditions within the abdomen has been repeatedly and rightly condemned. Previous abdominal operations usually render a satisfactory peritoneoscopic examination impossible because of adhesions. Infants and small children cannot be examined with the same degree of satisfaction as adults. Diagnosis made on the basis of inspection of the gross lesion alone, peritoneoscopically, without a biopsy, may be in error to the same extent that the diagnosis of any lesion on the basis of inspection of the gross specimen alone may be unreliable. Dangers of the procedure are few, but perforation of a viscus, severe hemorrhage, and spread of intra-abdominal infection have been known to occur. It seems desirable that peritoneoscopy should be performed by a surgeon rather than by a bronchoscopist, urologist, or internist. The surgeon is most familiar with the appearance of the abdominal viscera in health and disease. If an accident should occur, the surgeon may proceed at once as the condition requires and, if the examination indicates the desirability of exploration, this may be carried out without delay. Although

peritoneoscopy is a useful and valuable procedure under proper circumstances, undue enthusiasm and unwarranted indications for its use should be avoided. Likewise, too great acceptance of its reliability in certain types of cases should be curtailed.

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Morphine and Peritonitis

DURING the past several years, much has been published regarding the treatment of appendicitis. New concepts of origin and development have been advanced and old ideas of treatment have been revived and re-examined in the effort to reduce mortality and morbidity. Out of the mass of reported material, the principles of Murphy and Ochsner have again taken distinct form.

At present there are two well-defined, opposed groups; one advocating immediate surgery in all stages of appendicitis, the other counseling delay and nonsurgical methods in the presence of abscess or spreading peritonitis. Each group presents formidable series in support of their respective views, almost forcing the conclusion that both are correct. Examination of the evidence, however, suggests the possibility that the position of either faction is not invulnerable. Reports of cases operated upon indicate that extensive and intractable peritonitis may not occur as often as the proponents of delay believe. On the other hand, the adherents to Ochsner's principles present quite satisfactory evidence that, in the presence of extensive spreading peritonitis, surgery is of little value and is at times harmful. What variance of opinion there is appears to rest upon the diagnosis of the degree and extent of peritonitis which may attend any case of appendicitis. In fact, if this one variable factor could be removed by more accurate study and estimate, it is probable that much of the present conflict would disappear. There is no question but that the usual methods and means are sufficient to identify the presence of appendicitis, but recognition of peritonitis and its extent and degree is still difficult. If this is the situation and if this is the issue, it seems reasonable that every means be recruited and examined to make better diagnosis possible.

Steinberg[4] has recently presented a method of examination of peritoneal exudate which may serve as a basis, if correlated with other clinical findings. Even though it may prove to be of little immediate value, it may be of considerable worth as a basis for classification of statistical data. There is one other clinical method of approach which has been generally overlooked and which, because of its safety and ease of application, deserves further trial. That is the use of mor-

phine. Its use as a diagnostic agent has been reported from various sources,[1-3, 5] but its promise of usefulness has not been thoroughly tested. Morphine has long been decried as a source of confusion and danger to patients with acute abdominal disease. However, better knowledge of its action and a definite plan for its use make this teaching no longer sound. If, after careful preliminary inquiry and physical examination, morphine be administered in sufficient dosage to abolish pain, the cerebral component of the abdominal muscle spasm will be removed and re-examination will disclose with much greater accuracy the extent and degree of peritoneal involvement. As such evidence is of prime importance in diagnosis and is essential in determining the type of treatment, it would appear that a method which makes this more easily available merits consideration.

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Erratum

On page 925 of the December, 1939, issue, in the article by Ochsner, DeBakey, and Murray entitled "Absence of the Anterior Mediastinum With Report of Case Associated With Congenital Diaphragmatic Hernia" the last sentence in the first paragraph should read: " 'Since, in the dog, the normal history of the pleural expansion is an interruption of the process at a point just short of dissolution of the anterior mediastinum, it is not improbable that *unstable* development, whether in a dog or human fetus, might lead to complete disappearance of the mediastinal septum.' "

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

THE SURGICAL TREATMENT OF TUMORS OF THE STOMACH

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CARCINOMA of the stomach today accounts for one-fifth of the annual mortality from carcinoma in the United States.[23] By the time the diagnosis is made, resection can be carried out on only twenty-five of every one hundred victims of the disease, and of these only five have a reasonable chance of living five years.[36] While this figure, alarming as it is, holds for the disease as a whole, once resection is justifiable, the chances of five-year survival increase to 20 to 50 per cent.[44]

DIAGNOSIS

There is no train of symptoms or signs characteristic of gastric carcinoma. Occasionally marked secondary anemia, the result of progressive bleeding, is the only presenting symptom. Indigestion, anorexia, pain, vomiting, and weight loss are usually present and are reported in this order of frequency by Marshall and Taylor after an analysis of 291 cases. But, by the time most of these symptoms are apparent, the patient has frequently passed the point at which surgical removal of the lesion is feasible. Rivers and Dry point out that, except for pyloric lesions which cause early obstruction, it is the complications and systemic effects of the carcinoma which produce the symptoms. By this time the lesion has advanced beyond the bounds of operability. Nor does the duration of symptoms offer aid to diagnosis. In his series Morley reports the average duration of symptoms prior to operation to be 12.7 months for gastric carcinoma as compared to 10.3 years for gastric ulcer. Lahey, Swinton, and Peelen find the duration of symptoms to be 8.1 months for operable cases and 8.5 months for inoperable. Bull reports that 20.2 per cent of the inoperable cases had clinical symptoms for only 1 to 5 months. In spite of these obstacles, early diagnosis is occurring with greater frequency, according to MacCarty; he, as a pathologist, finds a greater number of small malignant lesions and reports that in 9.7 per cent of 410 specimens the malignant ulceration was the size of a quarter or smaller.

Gastric carcinoma appears most frequently in those in the fifth and sixth decades of life.[27] However, there are isolated reports, growing in number annually, of proved carcinoma of the stomach in

younger patients. For example, MacFarland describes its occurrence in a girl 21 years of age; Patterson and Gross, in a man 27 years of age. Almost any large series will include a few cases of carcinoma of the stomach in patients below the age of 30 years.

There is a definitely higher occurrence of gastric cancer in males than in females, the ratio being slightly more than three to one.[37] Dublin also points this out and estimates that carcinoma of the stomach is responsible for about one-third of all deaths from carcinoma in white males and one-fifth in white females.

It is widely believed that patients with carcinoma of the stomach have an achlorhydria, but this is unreliable. Comfort and Vanzant find the incidence of achlorhydria in cases of carcinoma of the stomach to be three times the normal. However, the range of acidity for men with carcinoma of the stomach varies from 0 to 90, which is only ten points short of the range for normal men. Comfort, Butsch, and Eusterman, in studying the gastric analyses of 79 patients of all ages who developed carcinoma of the stomach during an average period of observation of six years, discovered that the percentage of achlorhydria increased from 38 to 64.6 per cent. They believe that chronic gastritis as well as the tumor may be responsible for the frequent depression of gastric secretion after the development of gastric carcinoma. Robertson reports two cases in which there was a gradual disappearance of free hydrochloric acid during the entire period of observation, which, he believes, is the result of an intractable gastritis, secondary to the development of pyloric stenosis from the neoplasm. Shay and Schloss, in discussing the differential diagnosis of carcinoma and ulcer, call attention to the fact that in the case of ulcer there should be no drop in the gastric acidity in gastric analysis at three-week intervals, and that the occult blood reaction should disappear in the test meal. Great stress is placed on the disappearance of occult blood, since other improvements may occur with a malignant as well as a benign lesion. Apparently in early cases in which the diagnosis is questionable, a progressive lowering of the gastric acidity may be considered highly suggestive of carcinoma. On the other hand, Comfort and Butsch point out that the presence of any single laboratory or clinical finding does not justify an absolute diagnosis of cancer or benign ulcer if the diameter of the lesion is less than 4 cm.

The disclosure of a malignant lesion of the stomach by x-ray has reached such a high degree of efficiency that in competent hands a correct diagnosis may be made in 90 per cent of the cases.[53] X-ray studies, therefore, have become a prerequisite to diagnosis in any patient over 40 years of age having indigestion, dyspepsia, or mild epigastric distress which does not respond immediately to medical treatment.[43] In practice, it may often be difficult for the physician to convince his patient of the importance of thorough and usually rather

expensive x-ray studies for what seems a trivial complaint. But the physician must be alert to the danger and insistent upon accurate diagnosis if gastric carcinoma is to be discovered early at a resectable stage. In those instances when the roentgenologist is not certain whether the lesion is malignant or benign, it is customary for him to call it to the attention of the clinician and to request re-examination after a three-week interval of strict medical treatment.

Schindler and Gold report ten cases showing the value of gastroscopy in making an early diagnosis of gastric carcinoma. They believe that close cooperation between the gastroscopist and roentgenologist is essential in the routine periodic examination of patients with precancerous states, especially when the roentgen-ray results are negative or doubtful.

Relationship of Gastric Ulcer to Malignancy.—The question of whether or not a gastric ulcer undergoes malignant degeneration continues to be a moot point. Miller emphasizes the fact that the clinician should never forget that any ulcer of the stomach may be carcinoma and that it should be watched closely. Ransom quotes as the consensus of present-day opinion that about 5 per cent of benign ulcers undergo malignant degeneration if they resist treatment by dietary and other nonsurgical measures; Wulff believes that carcinoma arises from an ulcer in about 2.1 per cent of all cases. Scott and Mider state that most ulcers of the stomach over 2.5 cm. in diameter are malignant and that those smaller than 1.5 cm. are probably benign, but this observation is almost valueless as a guide to therapy in the individual case.

After three weeks of rigid medical treatment, Scott and Mider also divide all gastric ulcers into an ulcer and a carcinoma-suspect group. If the lesion is a benign ulcer, the pain should diminish the first week; all symptoms and occult blood should disappear in two weeks; and the size of the ulcer should decrease one-third of its area within three weeks. When any one of these three criteria is not fulfilled, the ulcer is placed in the carcinoma-suspect group, and surgery is advised. It is true that a few benign ulcers which are resistant to medical treatment because of adherence to the pancreas or liver will fall into this carcinoma-suspect group, and it is also true that the symptoms of malignant ulcer may be alleviated by medical treatment. Therefore, x-ray studies must be repeated every four to six weeks, if surgery is not performed, until all evidence of the ulcer has disappeared. If there is any recurrence of symptoms while the patient is under treatment, if the ulcer does not progress toward healing, or if it increases in size, operation should be advised.

Prepyloric gastric ulcers, as pointed out by Holmes and Hampton, are particularly likely to be malignant, although there is a controversy about the exact incidence.[83] Morley finds that 12 per cent of chronic

ulcers and 66 per cent of gastric carcinomas occur in the prepyloric region. Singleton[82] believes that any annular deformity in the pyloric region may well be considered malignant and that any ulcer within 2.5 cm. of the sphincter should be seriously regarded. However, in studying a series of 145 consecutive gastric ulcers in the terminal inch of stomach exclusive of the pyloric sphincter, he found the lesion was benign twice as frequently as it was malignant.[83] Sampson and Sosman, of the Peter Bent Brigham Hospital Roentgenological Department, find that 75 per cent of chronic ulcers in the prepyloric inch of the stomach are cancerous. It is now generally believed that ulcers in the prepyloric region should be considered malignant or potentially malignant, and should be subjected to strict medical treatment and repeated x-ray examinations over a prolonged period if immediate surgery is not carried out.

It is generally accepted that ulceration along the greater curvature is almost invariably malignant, regardless of size or location.

All *gastric ulcers, therefore, should be considered potentially malignant* and patients harboring such a lesion should be kept under close medical treatment augmented by repeated x-ray examinations, gastric analyses, and examinations of gastric contents and stools for occult blood. If the lesion does not respond to treatment within a period of three weeks, surgery is advocated.

OPERABILITY

The patient with gastric cancer should be given the benefit of an exploration, regardless of the apparent size of the neoplasm by physical examination and x-ray, unless there is clear and unmistakable evidence of metastasis. A rectal examination to determine the presence of implantation in the pouch of Douglas should be done routinely. In addition, Allen[3] emphasizes that an inspection of the anteroposterior view of the stomach filled with barium may give some clue as to whether or not there is metastasis, particularly in the region of the liver. If the stomach is normal in position, mostly to the left of the midline, it can be assumed that there is no extensive metastasis, at least in the region of the gastrohepatic ligament. Should the stomach lie mainly to the left of the vertebral column, extirpation of the organ is more feasible, since, when the stomach is drawn to the right, there is probably tumor in the gastrohepatic omentum. If there appears to be generalized metastasis, a needless exploration may be avoided by peritoneoscopy. Pack and Livingston point out that inoperability or curability is definitely evident on peritoneoscopy.

Finsterer believes that the only patients inoperable are *those in* whom there are distant metastases which can be *definitely demonstrated*, and that large palpable tumors, *advanced age, severe cardiac* or pulmonary disease, secondary anemia, or *advanced cachexia should*

not contraindicate operation. Walters[91] remarks that, regardless of the apparent extent of the malignant lesion as shown by x-ray, 15 to 20 per cent of the cases reported to be inoperable or on the border line, have sufficient stomach to permit a resection. Balfour[6] notes that the result for large tumors which at first appeared impractical of removal was a survival rate at the end of seven years of 33 per cent, as compared to 24 per cent for small tumors. Size alone, therefore, is not necessarily a deterrent to exploration and successful resection.

Bony metastasis from carcinoma of the stomach may be more common than supposed, according to Lawton, who suspected metastasis to the bone in 10 of 606 patients with carcinoma of the stomach. In 3, metastatic lesions of the bone were found at autopsy, despite negative x-rays. He concludes that the diagnosis must rest on clinical symptoms alone, because it is not always possible to confirm it by roentgenologic examination. Metastasis to the lungs is so uncommon that routine x-ray of the chest, other than the usual fluoroscopic examination at the time of the gastrointestinal series, is usually unnecessary.

The operability of carcinoma of the stomach varies markedly in urban and rural districts, being much higher usually in surgical centers.[44] MacGuire finds that 50 per cent of the clinical admissions for gastric cancer are operable; Marti, 55.8 per cent of 299 cases; St. John, Whipple, and Raiford find 13.6 per cent of 718 cases; Lewisohn and Mage, 14.3 per cent; and in 1935 Lahey, Swinton, and Peelen, 22.1 per cent which increased to 26.1 per cent in 1938.[52] Bull was able to perform radical operation in 23.3 per cent of the men and 30 per cent of the women with carcinoma of the stomach. Parsons and Welch report an increase in resectability during the past ten years of from 27 to 37 per cent. Livingston and Pack, in an analytical study and statistical survey of sixty years of surgical treatment of gastric cancer, conclude that from two-thirds to three-quarters of the lesions are unresectable when first seen. Marshall,[52] who submits all patients with gastric carcinoma to surgery unless there is evidence of widespread metastasis, such as to supraclavicular glands and to the pouch of Douglas, reports that 26 per cent of his patients with carcinoma of the stomach had operable lesions when the tumor was diagnosed. Maingot[49] believes that less than 30 per cent of the patients with cancer of the pyloric segment of the stomach can be subjected to radical resection. Balfour[5] reports an operability rate of 45 per cent for those cases in which exploration was carried out.

From all these reports it is apparent that only about one case in five comes to surgery early enough to warrant radical resection. This disheartening state of affairs serves to re-emphasize the importance of early, thorough investigation of every case of upper gastrointestinal distress.

PREOPERATIVE PREPARATION

The patient with gastric cancer is usually not a good surgical risk because of one or more complicating factors, such as anemia, malnutrition, or dehydration. There is also the danger of infection from soiling of the operative field from gastric contents, usually highly infectious, and of postoperative pulmonary complications. Attention to details in the preparation of the patient coming to operation is essential and has done much to lower the postoperative mortality.[69]

In addition to the routine laboratory studies on blood and urine, determinations should be made of the serum protein, vitamin C, and kidney function. Gastric analysis should always be done to determine the presence or absence of free hydrochloric acid, regardless of how obvious the diagnosis is. Every patient with gastric carcinoma should be typed, and there should be blood available for transfusion.[20] If the hemoglobin is below 40 per cent, a preoperative transfusion should be given.[27] Transfusion must also be given if the serum protein level is low. Under no circumstances should a patient with a low protein level be subjected to gastrointestinal anastomosis, because edema of the gastric wall not only may interfere with the anastomosis, but may cause a nonfunctioning stoma.[57, 69]

The patient with pyloric obstruction is placed on constant gastric suction and is encouraged to drink large amounts of water to wash out the stomach thoroughly. In such instances, it is obviously necessary to watch the blood chloride level and to maintain electrolytic balance by intravenous administration of 5 per cent dextrose in isotonic saline solution. If the patient receives sufficient fluid by mouth to insure a urinary output of at least 1,000 c.c. daily, no intravenous administration of fluid is required. However, in the presence of obstruction 5 per cent dextrose in isotonic saline solution or sterile water should be given in sufficient amounts, usually 2,000 to 3,000 c.c. per day, to insure a satisfactory urinary output.[27] If edema of the extremities develops, there is probably either a lowered total serum protein or an excess of chlorides. Therefore, in such instances immediate determination of the blood chlorides and serum proteins should be made. A transfusion may be indicated, or distilled water may be substituted for the saline solution, depending upon the laboratory findings.

If the patient does not have gastric retention, the stomach should be thoroughly washed out daily, starting several days before operation, to make certain that all coarse particles of food have been removed.[27] During this time the patient should be maintained on a high caloric, high vitamin diet.[21] Vitamin C, which is necessary for proper wound healing, may be supplied in adequate amounts by giving the patient orange juice with the addition of cevitamic acid.[3]

Gastric lavage should be repeated the night before operation and the following morning.[20] In addition, as pointed out by Horsley, it is advisable to attempt to sterilize the gastric contents by the administration of dilute hydrochloric acid, unless there is ample free hydrochloric acid present by gastric analysis. Gastric lavage with 0.25 to 0.5 per cent hydrochloric acid should be carried out several times during the twenty-four hours previous to operation. Hydrochloric acid, when sweetened to make it more palatable, may be given by mouth. This attempt at decreasing the bacteria count of the stomach is now widely used because peritonitis is one of the main causes of death following resection for gastric carcinoma.[30] When a culture of the gastric contents shows beta-hemolytic streptococci, Parsons and Welch state that sulfanilamide may be tried. While these methods may be of value, thorough mechanical cleansing of the stomach by gastric lavage is the most useful procedure. A small Levine tube may be left in place through the nose to maintain constant gastric suction during the operation and the immediate postoperative period.

In poor-risk patients with a high degree of pyloric obstruction and marked changes in blood chemistry, it may be judicious to perform a jejunostomy for feeding purposes.[25] After several weeks of jejunal feeding, the condition of the patient may improve sufficiently so that gastric resection may be contemplated with a moderate degree of safety.

Since pulmonary complications, along with peritonitis and infection, are one of the common causes of death following resection for gastric carcinoma, patients must not be subjected to surgery under any circumstances if there is evidence of respiratory infection.[20]

ANESTHESIA

There is no general agreement as to the choice of anesthesia; in fact, comparative mortality rates are reported for all types of anesthesia. Avertin (70 to 80 mg.) supplemented by ethylene or 1 per cent novocain infiltration is recommended by Meyer. However, Parsons and Welch state that avertin as a basal anesthesia has been found unsatisfactory, for it does not give as complete relaxation and results in more frequent postoperative complications. Finsterer prefers local novocain anesthesia with splanchnic block, because, he states, by its use the mortality from pneumonia in his cases is only 1 per cent. Lahey, Swinton, and Peelen in 1935 advocated the use of intratracheal ethylene or cyclopropane with regional field block with metycaine; but in a more recent article[37] announce a return to the use of spinal anesthesia, which they feel can be trusted to provide complete anesthesia and relaxation for at least three hours. Sise emphasizes that in most instances spinal anesthesia with pontocaine or nupercaine is quite satisfactory, but an anesthetist well-skilled in its administration and management is essential. If the opera-

tion is started with a general anesthetic, Allen[3] advises intratracheal administration with a closed machine. Especially for high resection, an intratracheal administration of anesthesia is recommended because it prevents regurgitation of the gastric contents into the bronchial tree during manipulation of the stomach at the time of operation. In addition, as pointed out by Pack and Livingston, hyperventilation of the lungs is also possible and is advantageous when reflex muscular inhibition, pressure on the thorax, or severance of costal cartilages has depressed respirations.

The majority of surgeons seem to use the type of anesthesia to which they are most accustomed and which existing facilities permit, resorting to intratracheal anesthesia usually, if a high or total resection is anticipated.

INCISION

The location of the incision may be varied, depending upon the site and extent of the lesion. A midline incision, or one just to the left of the midline, is most frequently used. Balfour[6] recommends making a small initial peritoneal opening so that if peritoneal implants are found the small wound may be closed immediately, thereby enabling the patient to be out of bed in a few days. This would appear to be an important point, since the percentage of cases having extensive metastasis is considerable. If it is apparent that a high resection will be necessary, a left rectus incision which can be extended well above the costal margin is preferred. Division of the costal cartilages or side extensions of the incision to the left are rarely necessary.

CHOICE OF OPERATIONS

After the abdomen is opened and no metastasis is apparent, the pouch of Douglas is first explored to see if there is seeding in the pelvis or cul-de-sac. A thorough exploration then follows.

The general abdominal examination must be thorough because it is not uncommon to encounter two or even more primary tumors in the same patient. While pathologists find this frequently, the clinical finding of two separate, distinct, and simultaneous carcinomas is rare. Pemberton and Waugh have reported the recovery to active life of a 57-year-old physician after the removal of primary carcinomas of the sigmoid and stomach. Maingot[50] has described a similar case in which primary tumors of the stomach and sigmoid were removed at one operation, with uneventful recovery of the 55-year-old female.

In addition to determining distant metastasis, the surgeon must also carefully palpate the omentum and the glands about each curvature to determine the extent of lymphatic extension. He should not be discouraged upon finding numerous enlarged nodes, because many of these may be the seat of chronic inflammation rather than tumor. Balfour[6] states that unless the enlarged lymph nodes beyond the range of removal

are proved malignant and there is other evidence of distant metastasis, it can be assumed that they are only inflammatory and that resection may be carried out.

The surface of the liver is visualized and palpated. The region of the gastrohepatic ligament and great omentum is similarly inspected for evidence of metastasis. Hunt[31] states that, as far as the stomach was concerned, 43 per cent of his cases were operable but that metastasis to the liver, extensive involvement of the lymph nodes along the lesser curvature and gastrohepatic ligament, or multiple remote peritoneal transplants ruled out the possibility of resection.

Regardless of how obvious the diagnosis may appear, a gland or portion of a metastatic nodule must be obtained for microscopic examination as proof that the lesion is not benign. The lesion may prove to be lymphoma which, unlike adenocarcinoma, is highly radiosensitive.

The amount of fixation of the neoplasm, as well as its extent, is then carefully determined. When there is diffuse metastasis and when free fluid is present in the abdomen, further procedures are of questionable value unless there is a high degree of pyloric obstruction. Even then, Balfour[6] states that gastroenterostomy is likely to prove disappointing in relieving the obstruction.

Palliative Operations.—A small metastasis to the liver or a single implant on the rectal shelf does not necessarily contraindicate palliative gastrectomy. If it is decided from a thorough abdominal examination that a radical resection is not to be done, the problem arises as to what type of palliative procedure, if any, is justifiable.

A gastroenterostomy may be done to relieve pyloric obstruction and to make the terminal months more bearable. In such instances Finsterer performs an anterior gastroenterostomy with enteroanastomosis, because marginal ulceration is a rare complication in cases of carcinoma of the stomach. Balfour[6] prefers the Devine exclusion operation as a palliative procedure for it affords complete relief from actual or impending obstruction and results in a very definite prolongation of life in comfort, while gastroenterostomy does not increase the average expectancy of life more than one month over exploration alone. Maingot[49] prefers the Devine exclusion operation for the inoperable case because the survival period is increased, probably due to the persistence of a wide-open stoma. Occasionally the excluded segment can be removed later at a second operation.

Pack and Scharnagel[65] advocate a two-stage operation, the first stage of which consists in exclusion of the carcinomatous segment of the pylorus and antrum and gastroenterostomy under local anesthesia. The patient is built up by a liberal postoperative diet to tolerate better the second stage. After the inflammatory reaction about the tumor has subsided, a partial gastrectomy is carried out. This procedure is followed

even in the presence of metastasis to the liver or supraclavicular nodes when the patient is in good condition and the stomach is sufficiently mobile.

Maes advocates the Eiselsberg-Witzel technique of creating a watertight permanent fistula to the jejunum for inoperable obstructive carcinoma of the stomach. Following this, frequent small feedings are given at the same rate that food would pass from the stomach into the intestinal tract in the normal process of digestion.

Any of these procedures carries a definite mortality. As the figures of Parsons and Welch show, in their series there was a postoperative mortality of 15.5 per cent for exploratory laparotomy and of 25 per cent for gastroenterostomy. Lahey, Swinton, and Peelen report a 6 per cent mortality following exploration, and a 40 per cent mortality following palliative operations. Livingston and Pack point out that the operative mortality for gastroenterostomy is as great as for attempted resection, yet the average extension of life is not more than two months. Balfour[5] finds that the duration of life for a group of patients having exploration only was five months; when gastroenterostomy was performed, the postoperative mortality was 11 per cent and only one more month, on an average, was added to the life expectancy. Anschutz hesitates to perform a palliative operation for gastric carcinoma, because the average length of life after operation in the 190 cases, he reports, was but six months.

It would appear that, in the presence of advanced carcinoma, short-circuiting procedures add little to the span of life. However, when the short-circuiting procedures are combined with the Devine exclusion type of operation, a longer period of survival may be expected.

Subtotal Resection.—If, after a thorough pelvic and abdominal exploration with careful examination of the liver, it is apparent that there is limited, or no, metastasis and that the mass is movable and can be resected, the surgeon must then determine the type of resection to be carried out. In order to insure complete removal of the growth, he must not have a fixed idea as to the type of surgical procedure he intends to perform, but must vary it with the individual case and the extent of the lesion found at exploration. This is a great tax on surgical judgment. In many instances in which the lesion might be considered inoperable by others, the surgeon of wide experience in gastric surgery is able to carry out successful resection.

Recent microscopic studies more clearly define the limits about the neoplasm where the gastric or duodenal wall should be divided to insure a resected margin free of tumor-cell involvement. Ruggieri, in studying the cardiac segment of the gastric wall in 19 instances, found cancer cells in the layers of gastric wall as far as 7 cm. from the macroscopic periphery of the tumor, and pathologic alterations of the tissue of the wall as far away as 9 or 10 cm. He, therefore, advo-

cates a wide resection. With this in mind, it is probably desirable for the surgeon to include in the resection at least 10 cm., or almost a hand's breadth, of normal appearing gastric wall above the neoplasm. Verbrugghen, after studying 50 resected specimens, comes to the conclusion that in gastric carcinoma at least 4 cm. of healthy gastric wall should be allowed from the edge of the ulcer along the lesser curvature toward the cardia in order that the resection may include the whole primary focus.

Castleman reports 21 cases of carcinoma of the pyloric end of the stomach in which there was extension of the tumor into the duodenum, varying from 4 to 23 mm. In most surgical specimens cancer cells were found at the distal cut edge, implying that the remaining duodenal tissue contained tumor. The lesion rarely involves the mucosa but spreads along the submucosa often in the lymphatics. He suggests that at least 3 cm. of duodenum should be removed in all gastric resections for carcinoma of the pylorus. Since it has been accepted for years that carcinoma of the stomach does not extend into the duodenum, surgeons perhaps are not particularly careful about how close to the neoplasm resection is carried out on the duodenal side. Usually, however, the crushing clamps customarily applied before dividing the duodenum will include at least 1 to 2 cm. of duodenal wall beyond the limits of the surgical specimen.

In addition to removing the tumor well beyond its normal limits and including a portion of the duodenum as well in lesions of the pylorus, many surgeons are recommending a complete excision of the omentum, which can be accomplished with little technical difficulty. Removal of the omentum, it is believed, will decrease the chance of leaving any metastatic tumor tissue. With these factors in mind, the surgeon must determine from the location and size of the tumor the extent of resection and the procedure most feasible to execute. The limits of safety should never be reduced in order to leave sufficient gastric wall to effect a preconceived plan of anastomosis.

Recently Pack and Livingston have thoroughly reviewed the various types of resection for gastric carcinoma. Some form of the Billroth II operation, either the Polya or Finsterer-Hoffmeister, is usually recommended over the Billroth I. However, the Billroth I type seems to meet a definite need in small neoplasms of the prepyloric region. In such instances a sufficiently wide resection may be carried out to permit gastroduodenostomy by the Billroth I method. Marti reports a mortality of 3.8 per cent in 26 cases of resection for carcinoma by the Billroth I method, in comparison with a mortality of 21.5 per cent of 130 cases resected according to the Billroth II technique. However, the instances in which he used the Billroth I technique were small, deep-seated carcinomas, so that a comparison of the two procedures should not be made on the basis of these figures. From his

statistics it would seem that for small lesions in the pyloric region of the stomach a Billroth I operation carries a definitely lower mortality rate. Cattell and Colcock feel that the Billroth I procedure is well adapted to cases of prepyloric malignant ulcer or cancer involving less than one-half the corpus of the stomach. It may well be the operation of choice in the elderly or poor-risk patient where the hazards of the operation may be in direct relation to the length of operation, shock, and widespread soiling. In addition, Marshall[52] believes that this operation is capable of readier and more rapid completion than a modification of the Polya operation and that the entire operation can be done above the transverse colon without gross contamination, an important factor in the elderly, poor-risk patient.

Pack and Scharnagel,[67] while admitting that the Billroth I operation has advantages in the treatment of malignancy of the stomach and gives a good physiologic reconstruction of the gastrointestinal tract, list its many disadvantages: there is danger of leakage at the so-called deadly triangle; it is difficult to bring the duodenal end to the gastric stump if the resection has been wide; there is danger of tension on the duodenum; if carcinoma recurs locally, it may cause pyloric obstruction, a complication that is less frequent in the modifications of Billroth's second operation; and there is too great a tendency for the surgeon to be conservative in the amount of stomach removed, making resection worse than useless in all but very early and very small lesions. The surgeon obviously must meet the requirement of removing not only the involved lymph glands, but also a liberal portion of apparently normal gastric wall, to be certain that all tumor cells which may have extended within the wall of the stomach are removed. The disadvantages of this operation are so much better known than its advantages that it has less frequent use than it deserves.

The majority of resections for carcinoma of the stomach, however, are carried out by some technique which anastomoses part or all of the open end of the gastric remnant to the jejunum. The chief differences in technique depend upon whether or not the jejunum is brought anterior to the transverse colon or posterior through the mesocolon, or whether the full gastric stump or only a portion of it is used for the anastomosis. Pack and Scharnagel[67] believe that the Billroth II modification permits a wider resection with less danger of leakage, and that it can be performed more quickly and in two stages when necessary. In addition, they believe that the Hoffmeister-Finsterer type of anastomosis, which requires a shorter jejunal loop than the typical Polya, lessens the opportunity for kinking and eliminates the fear of too rapid emptying of the stomach. Lewisohn and Mage also prefer the Billroth II operation because it facilitates a wide resection. Balfour[6] favors the Billroth II method of resection, since, when recurrence takes place after this operation, mechanical difficulties are infrequent.

Marshall[52] favors the Hoffmeister modification of the Polya procedure, bringing the jejunum up anterior to the transverse colon. A liberal loop of jejunum at least 25 cm. in length is used between the anastomosis and the ligament of Treitz. Many believe it makes little difference whether the proximal or distal loop of the jejunum is at the greater curvature, since good results are obtained with either method. The jejunum may be brought up through the transverse mesocolon posterior to the colon when the mesenteric omentum is quite fat or when the mesentery of the jejunum is very short. Walters[91] prefers an anastomosis posterior to the colon, using a short loop of proximal jejunum. If the transverse mesocolon is thick, he advocates the Polya-Balfour type anterior to the colon. A point 30 cm. from the ligament of Treitz is chosen, and an enteroanastomosis is carried out with a stoma 4 to 5 cm. in diameter, since the proximal loop distends in about one-third of the cases, demanding enteroanastomosis later if this is not done at the time. Marshall,[52] on the other hand, does not believe that an enteroenterostomy is necessary when the resection is antecolic. There is no contraindication to the enteroenterostomy following resection for malignancy, although it is very definitely contraindicated when such a resection is carried out for ulcer, because of the danger of marginal ulceration. Allen[2] likewise prefers the posterior type of Polya anastomosis.

Lahey and Jordan describe a technical procedure of dividing the ligament of Treitz, permitting the transplantation of the proximal loop of jejunum entirely above the transverse mesocolon. This prevents the danger of hernia and avoids angulation of the proximal loop of bowel. They report its successful employment in twenty cases. Lahey, Swinton, and Peelen describe the technique of anastomosing the jejunum to the posterior wall of the stomach, then incising through the muscularis, and tying the individual vessels in the gastric mucosa beneath the muscularis. The anastomosis is completed without the use of clamps. The majority of surgeons routinely apply a crushing clamp similar to a Payr clamp with division of the stomach by actual cautery with or without closure of part or all of the gastric opening with silk or catgut sutures. Cutler and Zollinger[21] recommend the universal use of silk suture material in gastric surgery, with interrupted silk to the serosa and a continuous silk suture to the mucosa.

The technical steps of the operation are shortened by the use of some form of mechanical sewing clamp as advocated by Pack and Scharnagel.[66] They believe that the dePetz clamp, for example, gives greatest assurance against spilling the gastric contents; produces absolute hemostasis, making the application of one layer of sutures very rapid; and at the same time allows correct approximation of the wound edges without tension. The only difficulty which they point out is that it may not be applicable in very high resections. Marshall,[52]

likewise, closes the gastric remnant with a mechanical sewing clamp and then excises the portion at the greater curvature to provide a stoma for anastomosis to the jejunum.

The mortality following gastric resection for carcinoma is definitely higher than that following resection for ulcer. Balfour[6] reports a mortality for resection between 10 and 13.9 per cent; Lewisohn and Mage, 33 per cent; Finsterer, 10 per cent (estimated); Marshall and Taylor, 31 per cent; Marti, 19.1 per cent. Gray and Balfour believe that the mortality following partial gastrectomy should be close to 10 per cent. It is difficult to compare reports on mortality because the figure no doubt varies with the type of case available for operation, the definition of operability, and other factors. The distressing part of the entire situation is the relatively small number of patients who come to surgery early enough to have a subtotal resection for a lesion limited to the stomach.

A small number of patients may expect a survival period of five or more years following subtotal gastrectomy. Lewisohn and Mage, in following up 88 patients over a ten-year period, find 10 well for five years or more following resection, 3 of whom had a survival period of more than ten years. Only 2 of this group were below the age of 50 years at the time of operation. Bull states that patients with carcinoma of the stomach who undergo resection have an average life extension five to six times longer than the patients with carcinoma of the stomach who do not, and he urges that at operation every effort be made to perform resection. Finsterer gives the incidence of permanent cure as between 22.2 and 27.6 per cent in cases having resection, the lower figure applying to cases of ulcer carcinoma. Lahey, Swinton, and Peelen report 1 man alive and well twelve years after radical resection. Marti states that, of 32 males undergoing gastric resection at least five years previously, 6 are still living; and of 25 females, 8 are living. Parsons and Welch say that 20 per cent of the patients in their series who underwent resection survived five years. Thiesen, in surveying a group of 184 patients in whom three-quarters or more of the stomach was resected, finds that 33, or almost 18 per cent, were living and well after five or more years. Sixteen, or almost one-half of the patients living at this time, had involved lymph nodes at the time of operation. When the growth and lymph nodes can be excised, there is a 30 per cent chance of a five-year cure, a 48 per cent chance when lymph nodes are not involved, and an 18 per cent chance when lymph nodes are involved.[91] Balfour[5] believes that Broder's grading of malignant tumors is a most important prognostic factor. Patients having lesions of a microscopic grading of I and II show a 63 per cent survival after five years and 55 per cent after ten years; those with a grading of III or IV show only a 20 per cent survival after five years. Livingston and Pack, from a study of 14,000 cases of gastric cancer, conclude

that the degree of success following resection exceeds that attained in the care of any form of strictly internal cancer and approximates or equals that obtained in the management of many external or readily accessible varieties of malignant tumors.

The survival period, therefore, depends not so much on the size of the tumor as it does on the location and presence of glandular metastasis and, like tumors elsewhere, on the rapidity of cell growth.

POSTOPERATIVE CARE

The avoidance of shock and pulmonary complications is the primary concern in the postoperative care of the gastric case. If blood loss has been great, immediate transfusion is given, although some surgeons prefer to give 500 c.c. of citrated blood during the operation. The position of the patient is changed frequently; the lungs are hyperventilated with carbon dioxide. In addition, after a prolonged gastric operation, Marshall advocates the use of an oxygen tent. The respiratory rate should not be cut down too much by morphine; nor should the abdominal binder be tight enough to hinder free excursion. Postoperative atelectasis may be relieved by aspiration through a bronchoscope.

Constant gastric suction is resumed through the Levine tube, which is often left in place during the operation. Water in sips is allowed after twenty-four hours. The fluid balance is maintained by intravenous or subcutaneous administration of 5 per cent dextrose in amounts up to 3,000 c.c. a day. With adequate fluid intake, the urinary output will be at least 1,000 c.c. a day. If edema develops, chloride and serum protein determinations are made; distilled water is substituted for saline solution; and a low protein level is raised by transfusion. The diet is slowly increased in accordance with the Sippy regimen. Solid food is withheld until the fourteenth or fifteenth day. Should there be a tendency to vomit, constant gastric suction is resumed and maintained for as long as is necessary. For several months after extensive resection the patient is advised to eat five small meals a day, with a gradual return to the usual three.

TOTAL GASTRECTOMY

The removal of the entire stomach in an attempt to eradicate malignant disease located near the esophagus is occasionally justifiable. Although relatively few successful cases of total gastrectomy have been reported, the records of most large clinics probably show one or more survivors of this operation. It is obviously an operation of great magnitude with resultant high mortality.

Total gastrectomy may be advisable for a malignant lesion, located high in the fundus and confined entirely to the stomach. The esophagus should show no involvement by x-ray examination or esophagoscopy; neither should there be evidence of metastasis. As pointed out by Allen,[3] the thin, ptotic individual with a short anteroposterior diameter

of the body is a more suitable patient for this procedure than the heavy, barrel-chested person. But in any case, the general condition of the patient must offer reasonable assurance of a successful outcome or total gastrectomy should not be attempted.

The preoperative preparation of the patient for total gastrectomy should follow the same routine as for subtotal resection, including the usual gastric lavages of dilute hydrochloric acid. Before the anesthesia is started, a Levine tube may be inserted into the stomach, permitting suction as desired during the resection. This serves to prevent soiling of the operative field and lowers the incidence of subsequent peritonitis.[2] At the completion of the anastomosis the Levine tube is directed down the distal arm of the jejunum, to remain in place during the early days of the postoperative period. At least 1,000 to 1,500 c.c. of blood must be available for transfusion. Because of the high incidence of postoperative pulmonary complications following gastrectomy, it is essential that the patient be free of respiratory infection.

If a general anesthetic is to be used, its administration through an intratracheal apparatus with a closed machine is advisable.

The abdomen is explored through a left rectus incision. If a total gastrectomy is indicated, the left rectus incision is carried well up to the xiphocostal angle. In such instances Clute and Albright[15] advocate the mobilization of the left lower costal outlet by cutting the sixth and seventh costal cartilages. It should be re-emphasized that the surgeon, before attempting total gastrectomy, should be certain that there is no involvement of the lower end of the esophagus, making it impossible to mobilize and use it for anastomosis.[14] This point should be determined before the duodenum is divided and the entire blood supply to the stomach is resected. If the esophagus is involved, the thoracic approach, as successfully followed by Marshall,[51] may be advisable.

At operation the tumor involvement may not be as extensive as it first appeared, and it may be possible to leave a rim of stomach attached to the esophagus to complete the anastomosis. Every effort should be made to save a margin of stomach, if possible, since the mortality rate is much lower if the anastomosis is done to a small gastric remnant than to the esophagus.[2] When any stomach at all, even an inch, remains, the operation cannot be classed as a total gastrectomy.

After the duodenal stump has been closed and the blood supply to the stomach has been clamped and tied, attention is directed toward exposure and preparation of the esophagus for anastomosis. The mortality is perhaps related to the amount of esophagus that can be exposed in each patient, because adequate exposure facilitates the anastomosis and avoids subsequent tension on the suture line. Turner's suggestion of dividing the diaphragmatic attachment of the left lobe of the liver has met general approval, for it permits retraction of the liver medially, thereby affording better exposure to the cardia and lower esophagus.[2]

Lahey emphasizes the importance of dissecting a peritoneal flap, both anterior and posterior to the esophagus, to which the jejunum may be subsequently anchored, thereby relieving the suture line of the weight of the long jejunal loop with its attached mesentery. Further exposure of the esophagus is obtained, as pointed out by Allen,[2] by sectioning the vagus nerve until 2 to 6 cm. of the esophagus can be exposed.

Several methods of lessening the technical difficulties encountered in anastomosing the jejunum to the esophagus have been presented. Lahey and Walters[24] prefer to use the stomach as a tractor until the posterior layer of sutures between the esophagus and jejunum has been placed. A long loop of jejunum is selected which, by repeated trial, shows a mesentery sufficiently long to permit anastomosis to the esophagus without increased tension. This loop of jejunum is brought up anterior to the transverse colon after the placement of the initial layer of sutures. The esophagus is opened on its posterior wall, and an opening of similar size is made in the jejunum. The posterior mucosal layer of sutures is now placed before the anterior wall of the esophagus is finally divided and the specimen is removed. Allen,[2] on the other hand, removes the stomach and applies long right-angle clamps to the region of the esophagus, with traction sutures on either angle. Following Roeder's suggestion, he sews the jejunum to the diaphragm posteriorly, and finally anteriorly, to insure complete anchorage about the stoma and to prevent tension on the suture line. He prefers to use an enteroenterostomy at the base of the two arms of the jejunum with a Witzel enterostomy into the jejunum distal to the enteroenterostomy, while Lahey believes this is unnecessary.

Although successful total gastrectomies have been carried out by anastomosing the duodenum to the esophagus, Allen[2] clearly shows that this is an undesirable technique because of the high mortality which results.

The operative mortality of total gastrectomy is difficult to evaluate, because most clinics report only successful cases. On the average, it is probably in the neighborhood of 50 per cent, although a few individual surgeons have shown an improvement over this figure. Holst reports 7 cases of total gastrectomy, 6 for cancer and 1 for general polyposis with diffuse bleeding. The patient with polyposis was in good condition two and one-half years after operation and was able to work; and 1 of the cancer patients was living fifteen months after operation and had gained 10 kg. Walters[24] reports 20 patients with total gastrectomy, 4 of whom lived from two to three and one-half years. Allen,[2] in a series of 16 patients with total gastrectomy, states that of the 8 survivors 5 are now living. One of these 5 has lived four and one-half years after operation without recurrence of symptoms. Lahey reports 1 patient living three and one-half years after total gastrectomy.

Food by mouth is withheld until the fourth day following operation, when gruels and liquids are started. Small feedings of readily tolerated foods are gradually added, until by the fifteenth day the patient is getting five small meals a day. Concentrated, high caloric foods should not be given, for these frequently initiate diarrhea. The diet of patients following total gastrectomy requires considerable attention until the jejunum has dilated to act as a reservoir for food.

Some patients are benefited by the administration of small doses of hydrochloric acid. In addition, the patient will probably profit from moderate doses of iron, although the clinical picture of pernicious anemia has not been emphasized by those reporting this operation. Tateno reports 3 patients with total gastrectomy who survived from 135 to 193 days after operation, in 2 of whom general weakness and hypoplastic, hyperchromic anemia developed.

Holst concludes that the nutrition absorption of the intestinal canal is only slightly affected after gastrectomy. It is apparent, therefore, that a patient can get along fairly satisfactorily without a stomach, with only a moderate restriction as to the frequency and size of regular meals.

FREE PERFORATION OF GASTRIC CARCINOMA

In rare instances (4 per cent) carcinoma of the stomach may result in a free perforation.[56] As Aird points out from studying 71 such cases collected from the literature, two-thirds of the cases resemble a perforated ulcer. In one-third of the cases the perforation is more or less silent with little pain and perhaps slight abdominal rigidity. McNealy and Hedin report that a correct diagnosis was made in but 31.6 per cent of their cases before operation. They also add that, while carcinoma of the stomach may perforate irrespective of the location of the lesion, the lesser curvature, the prepyloric region, and the cardiac end were the most common sites of perforation in their series. They urge routine biopsy of all perforated gastric ulcers, for at the time the perforation is closed it is often difficult to determine whether or not the lesion is malignant without microscopic examination.

Patients with perforated carcinoma of the stomach are usually poor risks for surgery (mortality 50 to 60 per cent), many of whom can survive only the minimum of surgery.[1, 22] Therefore, simple closure of the perforation with or without gastroenterostomy is probably the safest immediate treatment. Since the aim of surgery is to remove the carcinomatous lesion, if possible, simple closure should be followed by resection when the condition of the patient will permit. Peritonitis may occur in association with carcinoma of the stomach without actual free perforation.[1] Fifty per cent of the reported cases showed metastasis at the time of perforation.[1] Brunschwig and Heinz emphasize conservative management with simple closure of the perfora-

tion to be followed by a partial gastrectomy after the patient has recovered. Resection should not be delayed too long after closure. Fleming reports a case of perforated gastric carcinoma in which the area about the perforation was cauterized and the opening was closed with through-and-through sutures, with inversion of the stomach wall. Two weeks later a partial gastrectomy was performed, with recovery of the patient.

BENIGN TUMORS

Benign tumors of the stomach are relatively rare, the incidence, according to Eusterman and Balfour, being 1 benign tumor to 200 malignant tumors. Hunt[32] concludes that benign lesions make up 0.5 to 5 per cent of all gastric neoplasms. Minnes and Geschickter state that approximately 5 per cent of gastric tumors are benign. They collected 931 benign tumors from the literature and divided these into four groups: 35.2 per cent, epithelial; 55.9 per cent, mesenchymal; 4.3 per cent, endothelial; and 4.1 per cent, cysts. Gray and Wood collected 10 cystic tumors of the stomach from the literature and 3 from the files of the Mayo Clinic.

The diagnosis of benign lesion of the stomach is usually made by roentgenologic examination and may be suspected if there is an unexplained anemia. The anemia, however, may progress until it strongly suggests pernicious anemia. Therefore, Priestley and Heck urge that in all cases of primary anemia the stomach be carefully examined by x-ray. Dyspepsia in some form is reported in 20 per cent of the cases; pyloric obstruction, usually intermittent, occurs in 10 per cent.[24] McLaughlin and Conlin discuss at length pedunculated gastric tumors. They found 10 to 20 per cent of benign gastric neoplasms develop on pedicles and can produce pyloric obstruction. They also state that 30 to 40 per cent of pedunculated tumors in the stomach show malignant degeneration.

Because of their tendency to undergo malignant degeneration, benign tumors should be resected.[33] Balfour[6] believes that, when a tumor which has been bleeding is visualized by x-ray, it should be removed, because a considerable percentage of such tumors are either polyps of a low degree malignancy or they may become so. Chamberlin believes that a gastric polyp, although rarely encountered, is potentially a precursor of carcinoma and should be removed at once. During a study of 7,000 autopsies, Lawrence found 50 polyps, 18 per cent of which were malignant and over 50 per cent of which were multiple. The finding of multiple tumors at the time of operation should not be unexpected, although only a single lesion has been demonstrated by x-ray.[6]

Local excision of the growth may be all that is necessary, unless there is microscopic evidence of malignancy. Chaffin reports that local excision of benign tumors gives as good an end result as extensive

resection and carries a lower mortality. McLaughlin and Conlin advise partial gastrectomy. The type of surgery carried out will depend upon the extent of the lesion, its location, and its probable chance of being malignant.[33]

SARCOMA

Sarcomas are uncommon and probably constitute not over 1 per cent of gastric malignancies.[63] Counseller and Collins report that, of 4,733 cases of carcinoma of the stomach coming to surgery, 72 were sarcomas. Pack and McNeer[63] report 9 sarcomas of the stomach, which included 4 myxosarcomas, 3 primary lymphosarcomas, and 2 cases of general lymphosarcomatosis with secondary involvement of the stomach. Taylor estimates that 40 to 50 per cent of all gastric sarcomas are lymphosarcoma. He was able to collect 147 cases of primary lymphosarcoma from the literature, and added 5 new cases.

Sarcoma usually occurs in patients ten to fifteen years younger than those with gastric carcinoma.[24] The average duration of symptoms for gastric sarcoma is about eighteen months, but may range from six months to nine years.[24] Almost one-half the patients present themselves with an epigastric tumor, commonly situated in the antrum, as the chief complaint.[24] Obstruction, though, is rare. There apparently are no pathognomonic, clinical, or roentgenologic findings, although gastroscopy may prove of value.[88]

In general, resection appears to be the ideal procedure and should be planned if it is at all possible.[63] If this is not possible, well-planned irradiation therapy should be employed. In cases of myosarcoma and neurosarcoma, radiation therapy may not be of great value, but it is always indicated in cases of primary gastric lymphosarcoma, with beneficial and even curative results following.[63] The lymphosarcomas respond extremely well to radiation. Therefore, if a diagnosis of lymphosarcoma is suspected in a lesion which would carry a high risk if resection were carried out, this suspicion should be confirmed by biopsy, and radiation rather than resection should be advocated. Taylor remarks that thirteen patients with lymphosarcoma of the stomach have lived five to twenty-two years since the lesion was discovered, and emphasizes the desirability of establishing a histologic diagnosis of gastric neoplasm, regardless of how extensive the lesion may be, in order to insure the patient with lymphosarcoma the benefits of irradiation.

IRRADIATION THERAPY

Since less than one in twenty gastric neoplasms are radiosensitive, irradiation is but rarely used in the treatment of carcinoma of the stomach.[68] The initial response of cancer of the lesser curvature to irradiation is the best of any of the regional distributions, yet the rate of survival for periods over one year is less than that obtained for cancer of the pars media, fundus, and cardia.[64]

Lesions about the cardia are often difficult to diagnose. Kiefer, after studying 28 cases, found that there was no difference in the first symptoms from those of gastric malignancy in general. Stenström was able to diagnose by x-ray 38 cases of carcinoma of the fundus of the stomach in 300 cases of gastric cancer studied at the Maria Hospital, Stockholm.

Watson advocates the use of a Janeway gastrostomy in the treatment of lesions of the cardia and the esophagus. At the time that the gastrostomy is done, a biopsy is obtained. Through a small esophagoscope inserted through the gastric opening, the size of the lesion can be determined, permitting a better estimate of the dose of gold-filtered radon seeds necessary to control the lesion. By weekly gastroscopy through the gastrostomy stoma, the radium reaction may be followed, a checkup biopsy may be taken, and more radon seeds implanted if necessary.

Pack and his associates[68] feel that radon element packs are most effective for external irradiation of gastric carcinoma. Before treatment, however, the stomach should be thoroughly washed to avoid infection from the massive necrosis which follows irradiation. Preoperative irradiation is not recommended except in two-stage resections, when treatment may be given after gastroenterostomy and exclusion of the distal segment. Neither is prophylactic irradiation after radical resection advised as a routine procedure. They report four cases, with a survival period of two to seven years following the initial irradiation. Kaplan reports irradiation in three cases after a preliminary gastroenterostomy. The stomach was delivered into the wound. Twenty to forty radon seeds, containing 1 mc. of radon each, were implanted into the lesion. After the wound had healed, high voltage x-ray treatments, directed anteriorly and posteriorly, were given. Two of these tumors were pyloric and responded well to treatment. Strauss describes the use of surgical diathermy following a technique similar to that which he has advocated in cancer of the rectum. After a Witzel jejunostomy, the anterior wall of the stomach is sutured to the skin and an opening is made between the lesser and greater curvatures. The tumor is then coagulated by means of a special gastroscope. The efficiency of this treatment cannot be determined, since no late results have been recorded. Baum reports a patient with carcinoma involving the lower esophagus and cardiac portion of the stomach who lived for six years following high voltage x-ray therapy, which extended over a period of sixty-nine days.

Neither irradiation nor surgical therapy can offer more than meager hope to the patient with carcinomatous involvement of the cardiac end of the stomach.[35]

SUMMARY

1. Unfortunately there is no chain of symptoms characteristic of early carcinoma of the stomach. For this reason it would seem that, if

resection and carries a lower mortality. McLaughlin and Conlin advise partial gastrectomy. The type of surgery carried out will depend upon the extent of the lesion, its location, and its probable chance of being malignant.[33]

SARCOMA

Sarcomas are uncommon and probably constitute not over 1 per cent of gastric malignancies.[63] Counseller and Collins report that, of 4,733 cases of carcinoma of the stomach coming to surgery, 72 were sarcomas. Pack and McNeer[63] report 9 sarcomas of the stomach, which included 4 myxosarcomas, 3 primary lymphosarcomas, and 2 cases of general lymphosarcomatosis with secondary involvement of the stomach. Taylor estimates that 40 to 50 per cent of all gastric sarcomas are lymphosarcoma. He was able to collect 147 cases of primary lymphosarcoma from the literature, and added 5 new cases.

Sarcoma usually occurs in patients ten to fifteen years younger than those with gastric carcinoma.[24] The average duration of symptoms for gastric sarcoma is about eighteen months, but may range from six months to nine years.[24] Almost one-half the patients present themselves with an epigastric tumor, commonly situated in the antrum, as the chief complaint.[24] Obstruction, though, is rare. There apparently are no pathognomonic, clinical, or roentgenologic findings, although gastroscopy may prove of value.[88]

In general, resection appears to be the ideal procedure and should be planned if it is at all possible.[63] If this is not possible, well-planned irradiation therapy should be employed. In cases of myosarcoma and neurosarcoma, radiation therapy may not be of great value, but it is always indicated in cases of primary gastric lymphosarcoma, with beneficial and even curative results following.[63] The lymphosarcomas respond extremely well to radiation. Therefore, if a diagnosis of lymphosarcoma is suspected in a lesion which would carry a high risk if resection were carried out, this suspicion should be confirmed by biopsy, and radiation rather than resection should be advocated. Taylor remarks that thirteen patients with lymphosarcoma of the stomach have lived five to twenty-two years since the lesion was discovered, and emphasizes the desirability of establishing a histologic diagnosis of gastric neoplasm, regardless of how extensive the lesion may be, in order to insure the patient with lymphosarcoma the benefits of irradiation.

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14. The so-called benign tumor of the stomach tends to produce secondary anemia and to undergo malignant degeneration (30 to 40 per cent). Such tumors should be excised.

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earlier diagnosis is to be possible, any patient with persistent gastrointestinal complaints, regardless of how slight they may be, should have gastrointestinal barium studies. The average duration of symptoms before operation is eight to twelve months.

2. Every gastric ulcer should be considered potentially malignant. Patients with gastric ulcer should be placed on a rigid dietary regimen and should have frequent x-ray examination, regardless of early, apparent response to treatment. Gastric ulcers in the prepyloric inch and on the greater curvature, large gastric ulcers, and ulcers that do not respond to medical treatment within three weeks should be treated as malignant lesions.

3. Any patient with carcinoma of the stomach deserves exploration, irrespective of the size of the tumor, unless there is clear-cut evidence of distant metastasis.

4. Peritoneoscopy appears to be of value. Through its use, unnecessary exploratory operations may be avoided.

5. A rigid preoperative preparation, with special effort directed toward cleansing the stomach, is essential to reduce mortality from infection.

6. When first seen, approximately 75 per cent of the patients with gastric carcinoma harbor an unresectable tumor.

7. A palliative resection may be justifiable, even in the presence of limited metastasis. The Devine exclusion operation or gastroenterostomy is most commonly used. Short-circuiting operations in far advanced cases may fail to give symptomatic relief.

8. Microscopic studies show carcinomatous involvement of the tissues beyond the gross limits of the tumor for a distance of 2.3 cm. in the duodenal wall and for as much as 7 cm. in the gastric wall. Whenever possible, removal of gastric or duodenal wall well beyond the limits of the tumor is essential.

9. The number of successful subtotal and total gastrectomies is increasing.

10. The mortality for gastric resection for cancer is higher than that for ulcer and varies between 10 and 30 per cent. Palliative operations and exploration likewise have a high mortality rate.

11. The complications after gastric operations are about evenly divided among pulmonary complications, infections, and a miscellaneous group.

12. The average length of life after palliative operations is approximately four to six months. Five-year survival after gastrectomy is recorded in from 20 to 30 per cent of the cases.

13. One case in twenty of gastric carcinoma will respond to irradiation. Cases of lymphosarcoma respond well, and long survivals are recorded.

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The reviewer has devoted considerable thought and attention to the question of neurogenic vesical dysfunction (which is what the author means by "the neurogenic bladder"); nevertheless this book leaves him with a feeling of frustration and inability to understand the author's conclusions.

The author's classification is unsatisfactory in that the adjectives used to indicate the various types of dysfunction are not sufficiently descriptive and the various categories set up by him overlap too much. He distinguishes uninhibited, reflex, autonomous, and atonic types; the last certainly includes the second and third, since numerically the vast majority of cases of neurogenic vesical dysfunction are characterized by some loss of tone by the detrusor. This reviewer prefers to classify all neurogenic dysfunctions as sensory or motor, and to subdivide each of these into irritative and destructive types, chiefly because the resultant classification tells something of the behavior of the bladder as well as of the type of disease afflicting it.

There is not enough emphasis upon the role of the cystoscope both in the diagnosis of neurogenic dysfunction, in the recognition of complications, and in the differentiation of neurogenic from mechanical disturbances. It ought to be axiomatic that an indication for cystometry is also an indication for a cystoscopic examination, since the latter may reveal lesions which were unsuspected from the cystometrogram and which may be corrected surgically with relief of symptoms.

Despite these rather petulant criticisms, the book contains much of value; the charts of cystometrograms of various conditions will repay study. Still, it is a book to be read critically by someone already acquainted with the subject, rather than to be used as textual material by the uninformed.

Cirurgia do Megaesofogo. By Edmundo Vasconcelos and Gabriel Botelho. Paper. Pp. 434, with 150 illustrations. São Paulo, 1937, Companhia Editora Nacional.

Written in Portuguese, this extensive monograph is an elaborate and rather complete exposition of the subject of megoesophagus, or achalasia. Following a brief historical review of the condition, there is a detailed discussion of the various theories concerning its etiology. The authors are in accord with the generally accepted view that the condition is the result of disturbances in nerve supply of the esophagus, and present an excellent discussion of the theory and the facts supporting it. The innervation of the esophagus is clearly described. The normal physiology of the esophagus and cardia is considered in detail and the pathologic physiology in achalasia is discussed. Of particular interest is the authors' analogy between megoesophagus and megacolon. The experimental production of the disease in animals is reviewed and the authors' observations presented in details. Of interest in this regard is the possible relationship of beriberi and experimental B avitaminosis to megoesophagus, or achalasia. The characteristic clinical manifestations, the diagnosis, and the radiologic features are presented and considered in detail. The various forms of conservative and radical therapy are thoroughly discussed. The various types of operative procedures are described and the authors' experience with them is stated. The technique of these operations is illustrated by drawings which are clear and descriptive. The volume is profusely illustrated by photographs of gross and microscopic pathology, anatomical drawings, and roentgenograms. There are 627 references presented in alphabetical order which add considerably to the value of the monograph. However, it was observed that some of the original references have been omitted. The printing, which is large, well spaced, and consequently more readable, is done on heavy glazed paper.

Book Reviews

The Hospital Care of Neurosurgical Patients. By Wallace B. Hamby, M.D. Cloth. Pp. 118, with 24 illustrations. Springfield, Ill., 1939, Charles C. Thomas, Publisher. $2.

This book, which was written for nurses and the young physician, should meet a need by collecting in a small monograph material which is nowhere else to be found in any single treatise.

It gives in simple form essential anatomy; a description of the procedures that are peculiar to neurosurgery, such as spinal puncture, Quackenstedt test, injection of iodized oil, encephalography, ventriculography, etc.; and a description of such procedures as catheterization, vena puncture, and transfusion which are common to all types of surgery.

In a most simplified form it describes the whole range of common neurosurgical conditions and gives the treatment of each. Preparation of the patient for operation, postoperative care, and complications are treated in a clear and concise manner.

Controversial issues are passed over by a mere statement that they are controversial.

The final chapter concerns dressings of neurosurgical wounds.

It is difficult to treat a complicated subject in a simple yet inclusive manner as has been done in this book.

There are many figures, all diagrammatic line drawings, to clarify the text.

The book is recommended to answer the purpose for which it was written. Every nurses' training school should be familiar with this book, and those in hospitals caring for neurosurgical patients will find it essential to their library. It is also recommended for the neurosurgical intern.

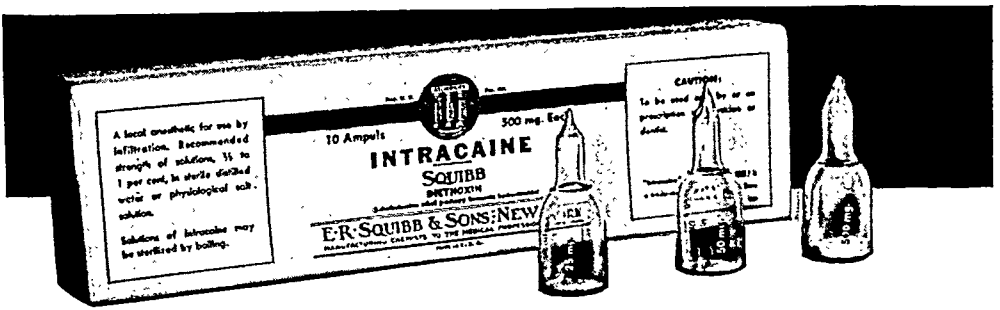
The Neurogenic Bladder. By Frederick C. McLellan, M.D. Cloth. Pp. 206, with 57 illustrations. Springfield, Ill., and Baltimore, Md. 1939, Charles C. Thomas, Publisher. $4.

This book consists of a description of cystometry, including the apparatus used, of the innervation and function of the urinary bladder, a classification of neurogenic vesical dysfunction with description of the various types, and a series of charts of illustrative cases with cystometrograms and clinical data.

The unfavorable impression which this work has made upon the reviewer is probably due to several factors. First is the author's lack of proper reverence for the English language. For example, one cannot justify speaking of "those bladders produced by lesions of the posterior roots," however interesting such a phenomenon would be if it actually occurred.

Some of the text is practically incomprehensible: "Cerebral function in bladder control would appear to be the cerebral or supranuclear inhibition over the bladder reflex as is seen in the adult over the infant's bladder" (?)!

Nor can one excuse misspelling the name of a contributor to the literature in more than one way in a single book. Moreover, the diagrams of the presacral nerve (plexus) are too much idealized in that they represent a plexus as a nerve trunk.



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[1] Rovenstine, E. A., and Cullen, Stuart C.: *Anesthesia & Analgesia* 18:86 (March-April) 1939.

[2] McIntyre, A. R., and Sievers, R. F.: Article presented at meeting Federation of American Societies for Experimental Biology, Baltimore, March 31-April 2, 1938.

[3] Sappenfield, R. S., and Rovenstine, E. A.: Article presented at the Forum of Anesthetists, St. Louis, May 15-19, 1939.

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Operative Orthopedics. By Willis C. Campbell, M.D. Pp. 1154, with 845 illustrations, 4 in color. St. Louis, 1939, The C. V. Mosby Co. $12.50.

The author's purpose can best be stated in his own words: "This volume has been written to meet the current need for a comprehensive work on operative orthopedics not only for the specialist, but also for many industrial and general surgeons who are doing excellent work in some branches of orthopedic surgery, and are making valuable contributions to this field." Everyone who has been working in the field of orthopedics recognizes the current need for such a work, and welcomes this excellent treatise by Dr. Campbell. All who have been practicing orthopedics for the past fifteen years will likewise gladly concede that no one is better prepared to write such a volume than Dr. Campbell and his associates. Those who have visited him and observed his work readily accept the truth of his statement: "In our private clinics and the hospitals with which we are associated, a sufficient amount of material on every phase of orthopedic surgery has been accumulated during the past twenty years or more to justify an evaluation of the various procedures. From this personal experience we also feel that definite conclusions may be drawn in regard to the indications, contraindications, complications, and other considerations entering into orthopedic treatment. In all surgical cases, mature judgment is required for the selection of the most appropriate procedure. With this in mind the technics which have proved most efficient in the author's experience have been given preference in the text. In addition, after a comprehensive search of the literature, operative measures have been selected which in the judgment of the author are most practicable."

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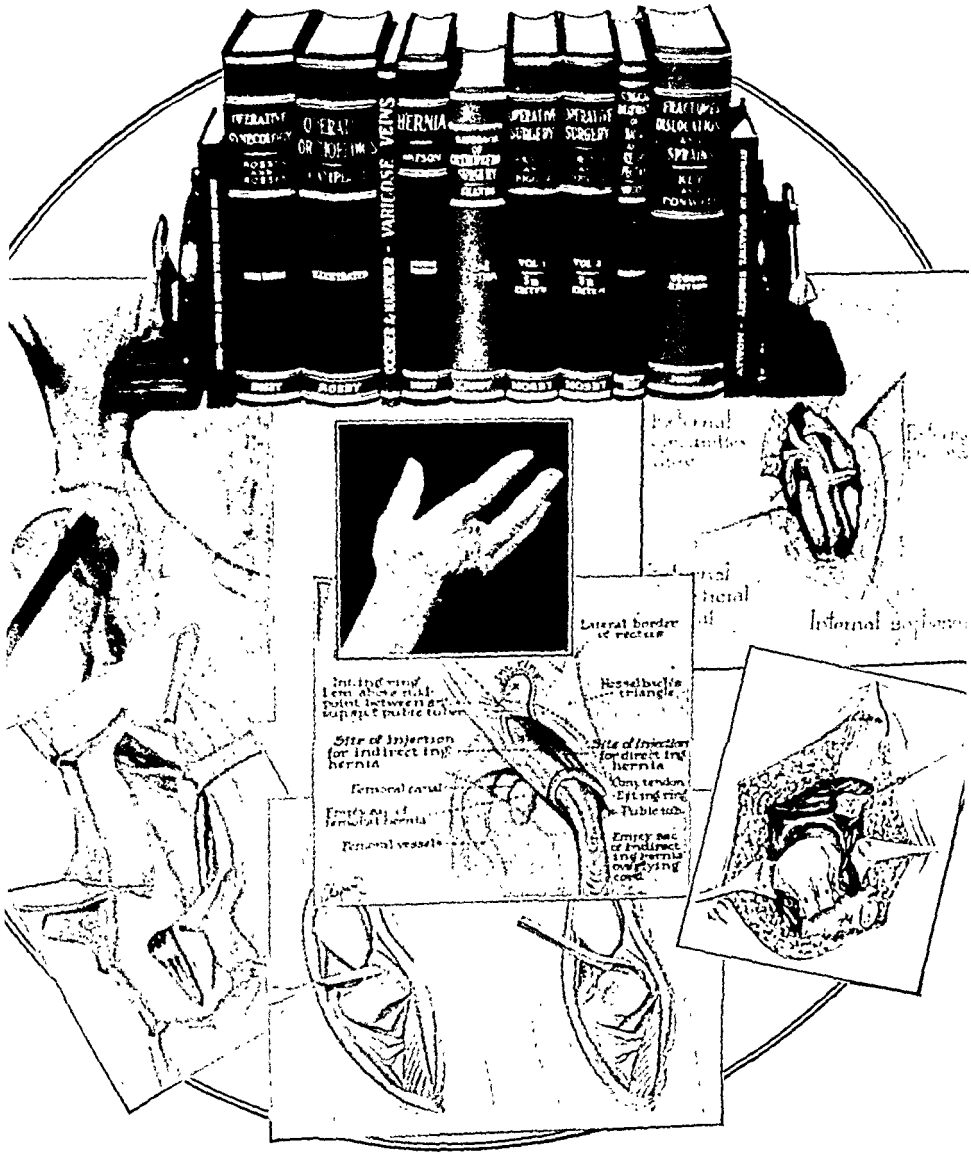
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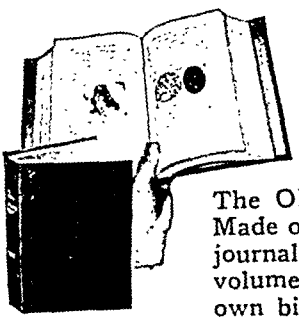
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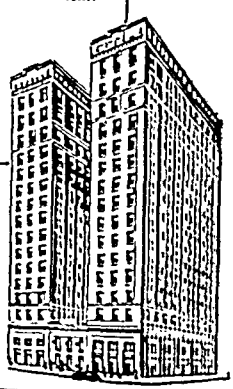
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THE SURGERY OF INJURY AND PLASTIC REPAIR. By Samuel Fomon, Ph.D., M.D. Cloth. Price, $15. Pp. 1409, with 925 illustrations. Baltimore: William Wood & Company, 1939.

This large book, which represents an immense amount of research, is an ambitious attempt to encompass within one volume the entire literature of traumatic surgery. The author admits falling short of the mark, as the special surgery of the neck, trunk and extremities was withheld for a future volume to supplement the present one, which deals with the structures of the exterior head. However, since almost half of the book is taken up with fundamental principles of surgical repair, it is quite evident that the most important part of the work is herein offered in complete form. The author has thoroughly analyzed the literature and presented every recognized point of view with regard to manifold aspects of traumatic surgery in general and presents them without bias so that the reader can judge for himself. The general preoperative and postoperative care of the patient, choice of anesthetics, methods of administering them, details of operating room procedure, care of shock, acid base balance and many other factors are presented thoroughly and to the last detail. Much space is devoted to the most elementary details, such as the incision, proper excision of tissue, rearrangement for suturing, types of sutures and suture material, wound dressings, tissue transplants and grafts, so that one need hardly look further for information to cover any imaginable situation. Certainly the profusion of illustrations, line and wash drawings, some with color, are in themselves a liberal education. The author evidently had in mind the average general practitioner, who usually sees the injured person first and whose initial treatment may have a great bearing on the ultimate result obtained. Yet even the experienced surgeon or the specialist in regional plastic surgery into whose hands these cases come later for the correction of traumatic defects will find much that is useful and clarifying in the abundant text. The special chapters on plastic surgery of the nose, eyelids, jaws and face, which include a considerable number of cosmetic procedures, follow the customary practice of the day and are presented simply, so that even the novice may grasp their frequently complex details. A voluminous bibliography follows each important chapter and should prove of utmost value to the student and research worker. This work of Dr. Fomon's must be seen to be appreciated, since it holds the answer to a vast number of questions that are frequently unanswered in books on general surgery. In this day and age of high speed, increasing trauma and a public that is plastic conscious, it behooves every surgeon and general practitioner to familiarize himself with the latest developments in these fields. Fomon's book should fill that need.

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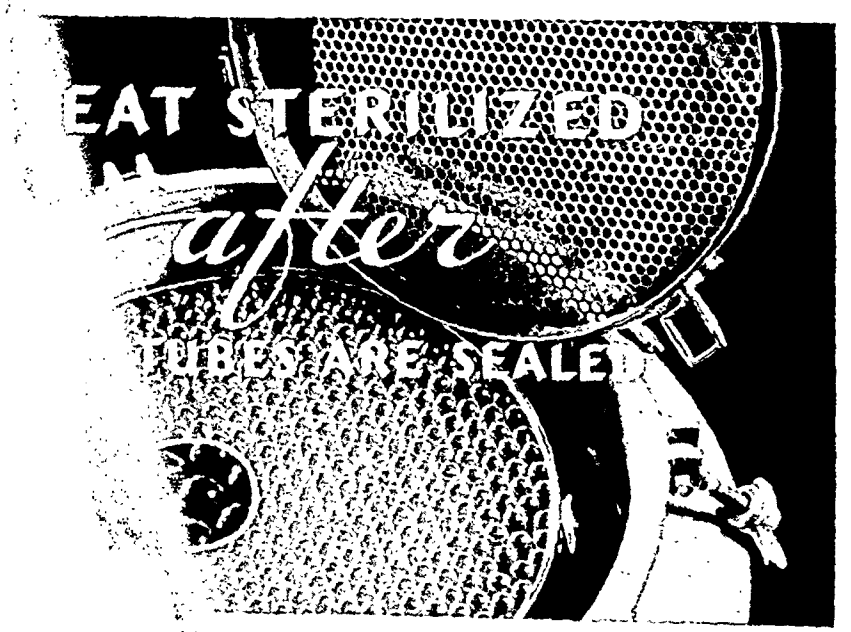
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Vol. 7, No. 6, June, 1940. Surgery is published monthly by The C. V. Mosby Company, 3523 Pine Blvd., St. Louis, Mo. Subscription price: United States, its possessions, Pan-American Countries, $10.00 a year; Canada, $11.50; Foreign, $11.00. Entered as Second-Class Matter January 26, 1937, at the Post Office at St. Louis, Missouri, under the Act of March 3, 1879. Printed in U. S. A.

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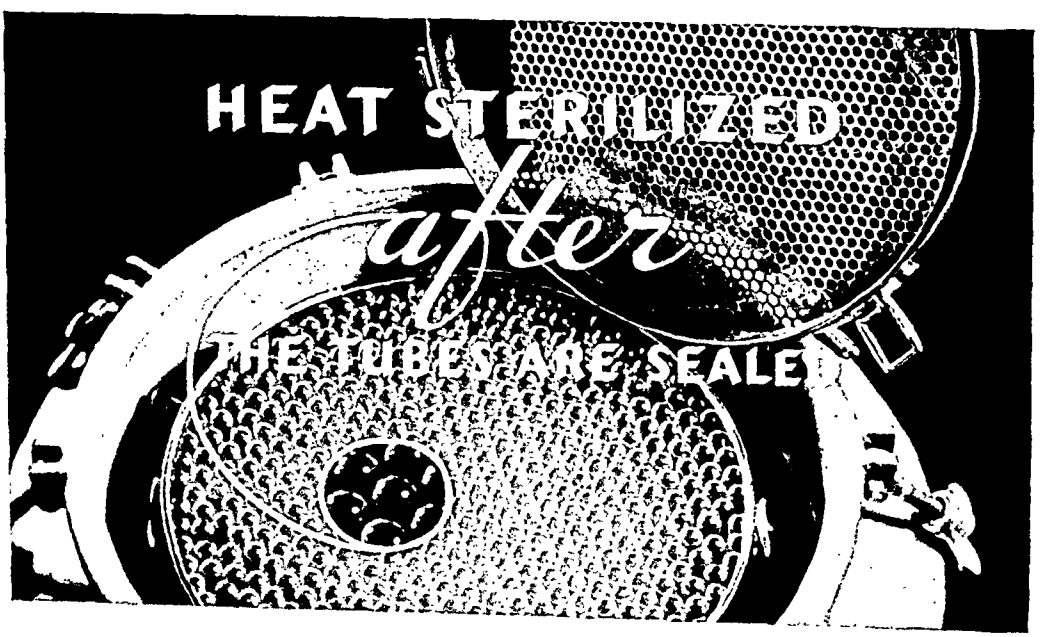
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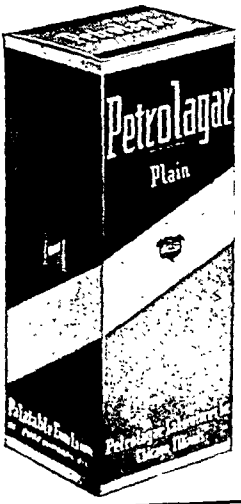
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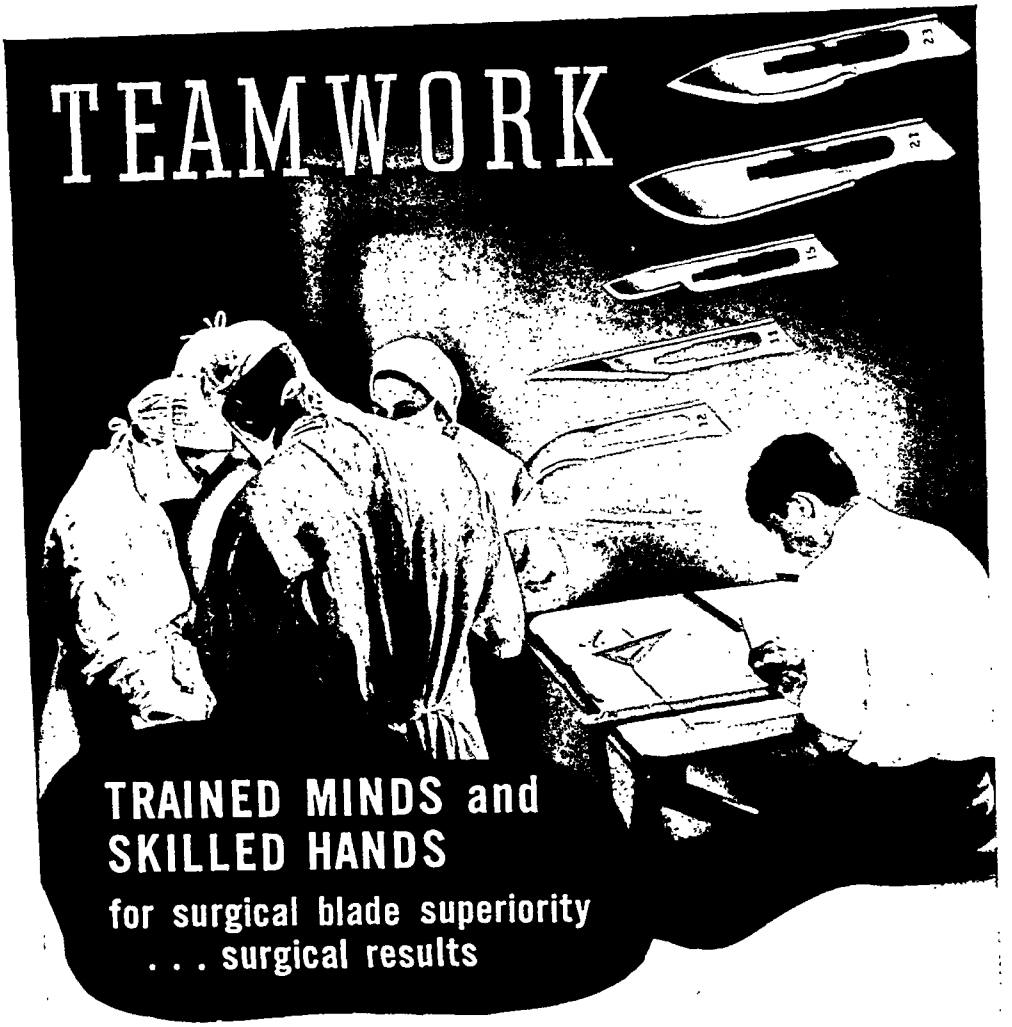
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Published June 1, 1940

Principles of Surgical Care

Shock and Other Problems

By Alfred Blalock, M.D.

Professor of Surgery, Vanderbilt University School of Medicine, Nashville, Tenn.

From the Foreword

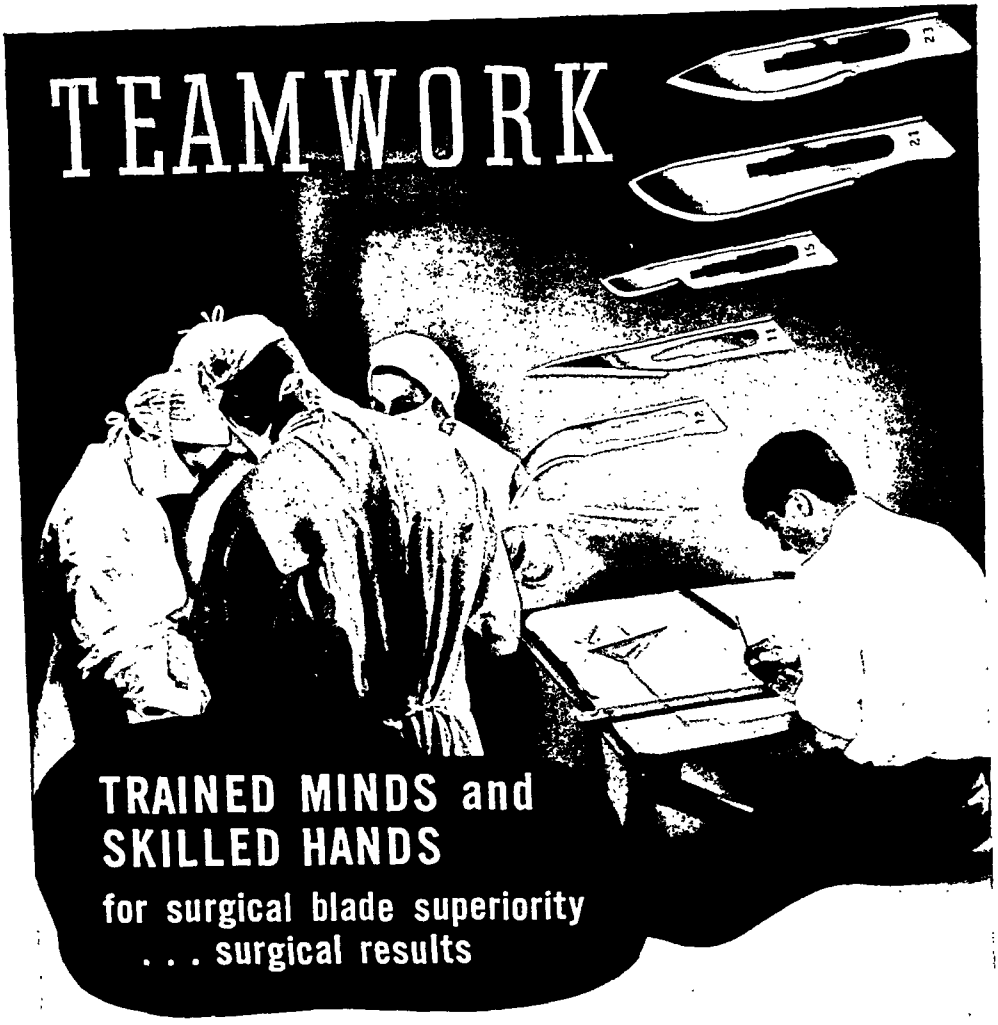
Shock or peripheral circulatory failure once was a surgical complication to be dreaded. However, now, in the light of recent intensive investigations of its causes, it would seem to be largely preventable. In this monograph the author considers those factors which from his personal clinical observations and studies in the experimental laboratory appear to be directly responsible for the development of postoperative shock. It is on these grounds that he advances principles of importance in the preparation of the surgical patient.

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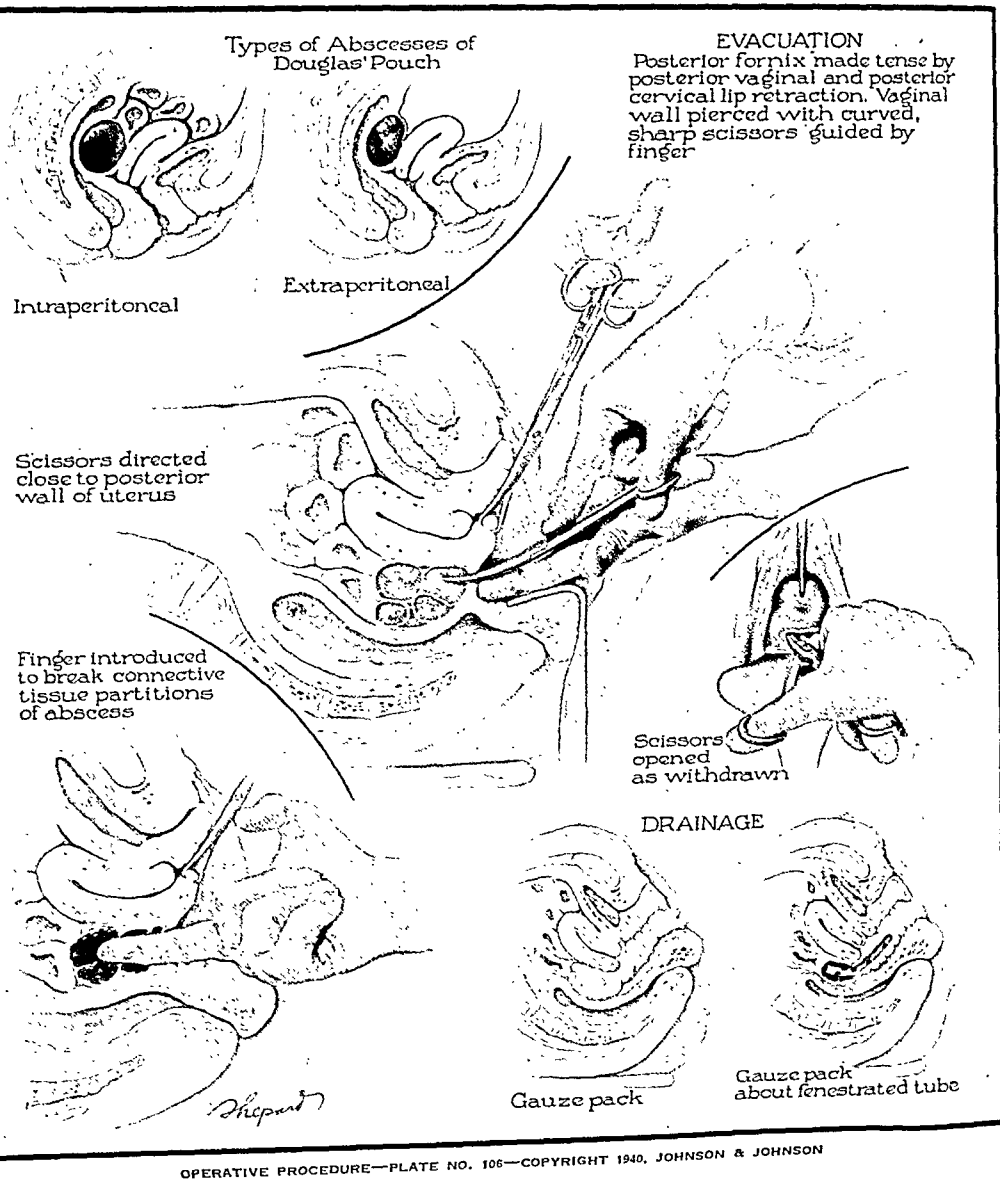
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SURGERY

VOL. 7 JUNE, 1940 No. 6

Original Communications

CHANGES IN PRESSURE IN THE ANTECUBITAL AND SAPHENOUS VEINS DURING ABDOMINAL OPERATIONS

JAMES ROSS VEAL, M.D., AND HUGH HUDSON HUSSEY, M.D.,
WASHINGTON, D.C.

(From the Surgical Service, Gallinger Municipal Hospital, and the Department of Medicine, Georgetown University School of Medicine)

THE FLOW of blood in the veins of the extremities normally is influenced by cardiac action, gravity, intrathoracic pressure, the volume of blood, muscular tone and exertion, and several other factors of relatively negligible importance. In normal persons resting in the supine position, the interplay of all these factors is finely enough balanced so that the pressure of the blood in the antecubital veins, for example, ranges at most between 50 and 150 mm. of saline solution. In addition, comparisons of the pressures in the antecubital and femoral veins of a normal individual show very slight differences.[1] It is to be expected, therefore, that direct measurement of peripheral venous pressure is a practical and sensitive method of detecting changes in the circulation in the large veins resulting from abnormal causes.

Elevation of peripheral venous pressure above normal occurs in a variety of disease conditions; for example, heart failure, acute and chronic cardiac compression, mediastinal tumors, pregnancy, intra-abdominal tumors, ascites, hepatic cirrhosis, venous thrombosis or other localized obstruction, and arteriovenous fistula. In some of these conditions the venous pressure is elevated generally; in others, obviously, the rise in pressure is restricted to a section of the body. Abnormal lowering of venous pressure is comparatively rare, but it has been observed in cases of shock.

Any condition that retards the flow of blood in the veins predisposes to venous thrombosis, and this predisposition is increased by combination with direct injury to the veins. Thrombosis in the femoral and

Received for publication, November 27, 1939.

iliac veins most frequently follows abdominal operations in the regions of the large veins, such as operations upon the gall bladder, stomach, and pelvic organs. Direct injury to large veins by surgical instruments during such operations should usually be obvious, but the effect of normal operative procedures upon venous blood flow is not so readily appreciated. It was our purpose in undertaking the present study to try to demonstrate the magnitude of this effect by measuring the changes in blood pressure in veins which conceivably might be affected by the operative procedures. For this purpose changes in the pressure of the blood in the veins of the upper and lower extremities were measured during ten standard abdominal operations (Table I). These were

TABLE I

CASE	OPERATION	ANESTHESIA	PREOPERATIVE V. P.*		MAXIMUM OPERATIVE V. P.*		POSTOPERATIVE V. P.*	
			ANTECUBITAL	SAPHENOUS	ANTECUBITAL	SAPHENOUS	ANTECUBITAL	SAPHENOUS
1	Colostomy	Local (novocain)	170	100	170	100		90
2	Cholecystectomy	Local (novocain)		85		290		155
3	Hysterectomy	Gas-ether	175	240	205	380	130	270
4	Appendectomy (McBurney incision)	Ether		80		130		80
5	Splenectomy (idiopathic hemolytic icterus)	Spinal-ether	220	480	230	520	100	470
6	Repair of ventral hernia	Spinal	60	70	110	150	85	110
7	Abdominal exploration and biopsy of liver	Spinal	70	110	75	140	70	100
8	Gastroduodenostomy	Spinal	135	45	135	75	120	55
9	Hysterectomy	Spinal	105	100	190	280	65	110
10	Colostomy	Spinal		80		220		80

*V.P., Venous Pressure in millimeters of saline solution.

selected with a view to including the exploration of each abdominal quadrant and the involvement of all the main abdominal organs in some way during one or more of the operations.

During each operation measurements were made repeatedly and simultaneously by the direct method in the antecubital and saphenous veins. Because of its relative inaccessibility, the saphenous vein was exposed under local anesthesia by a short vertical incision over the saphenofemoral junction. The venous pressure apparatus employed consists of a 19 gauge needle fitted to a three-way stopcock connected at one inlet to a reservoir of saline solution and at its other inlet to a calibrated

glass tube of 4 mm. bore used for measuring the pressure in terms of millimeters of saline solution (Fig. 1). When this apparatus is in use, measurements can be made repeatedly, the measuring tube being refilled each time from the reservoir; and in the intervals between measurements the system can be kept clear by allowing saline solution to flow slowly from the reservoir through the needle. The largest amount of physiologic salt solution introduced into the veins of any of the patients in this series during operation was 550 c.c.

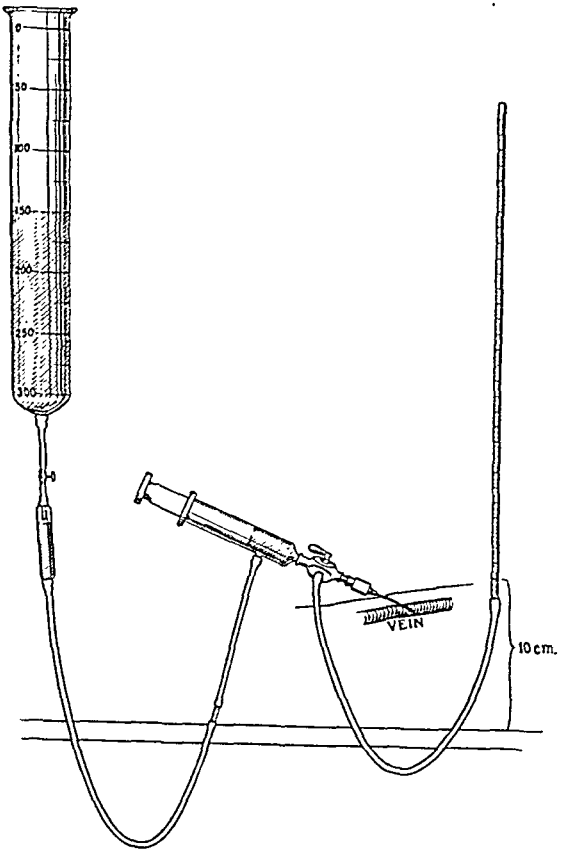


FIG. 1.—Venous pressure apparatus, showing attachment of saline solution reservoir to manometer through a three-way stopcock.

Since all operations were performed with the patients in the supine position, the zero level adopted for venous pressure measurements was a point approximating the position of the right auricle. This point was arbitrarily placed at a distance 10 cm. from the surface of the operating table in accordance with the recommendation of Lyons, Kennedy, and Burwell.[2] By this method the pressure in the antecubical vein normally ranges from 50 to 150 mm. of saline solution, and the pressure in the saphenous vein might be expected to be nearly identical.

PROCEDURE

The general procedure was practically the same in each of the ten operations studied. The patient was placed in the supine position with a sphygmomanometer affixed to one arm and the other arm abducted to an angle of about 60 degrees and supported by an arm board. One venous pressure apparatus was then set in use at the antecubital vein of the abducted arm. Next the abdomen was prepared, including the femoral triangle on one side, and sterile drapes were applied. The saphenous vein was then exposed and the other venous pressure apparatus set in use at this point. Preoperative measurements of the arterial blood pressure and the venous pressures in the arm and thigh were then obtained simultaneously, and the operation was started. At designated intervals during the operation measurements of the arterial blood pressure and venous pressures were repeated in order to ascertain the influence upon them of each operative maneuver.

DISCUSSION

The operations selected for this study differed widely in scope and character, but certain steps were common to all. The effects of these steps are shown in Table I and Figs. 2, 3, 4, 5, and 6. In general, the influences of anesthesia on the venous pressures were not great and were in no way unexpected. In those operations in which spinal anesthesia was employed, measurements were not obtained before administration of the anesthetic agent, but it is safe to assume that differences in readings before and after such anesthesia would not be remarkable except in cases in which relaxation of rigid abdominal muscles occurred, with a consequent diminution in intra-abdominal tension and fall in venous pressure. The vasodilating effect of spinal anesthesia probably has no influence upon the venous pressure in the lower extremities. This assumption is supported by reports[3-5] which show the absence of direct influence of arterial blood pressure on venous pressure and by the finding in our own cases that spinal anesthesia did not cause the venous pressure in the saphenous vein to be significantly lower or higher than that in the antecubital vein. Of course, at times when the patient became restless and made struggling motions with the upper (unanesthetized) part of his body, the antecubital pressure rose, while the saphenous pressure remained unaffected.

During the process of infiltration of the patient's tissues with a local anesthetic agent, there was often a temporary, slight elevation of the venous pressures in both extremities. Apparently this was the result of irregularity of breathing and contraction of the abdominal muscles because of pain and apprehensiveness. A similar effect was noted during the first stages of anesthetization with ethylene and ether, and this was markedly accentuated by active struggling of the patient. When the stage of relaxation developed, the venous pressures tended to return

to original levels and remain there. The greatest rise directly related to the anesthesia at any time was 80 mm. of saline solution. (Fig. 2.)

In this series of cases opening the peritoneal cavity had no effect upon the venous pressure. In one case the peritoneal cavity was opened almost from the symphysis pubis to the xiphoid process, but the venous pressures in the arm and thigh remained practically stationary (Fig. 3). This finding was also true in the cases operated upon under local anesthesia in which there would not be the same loss of abdominal muscle tone that occurs with spinal or general anesthesia.

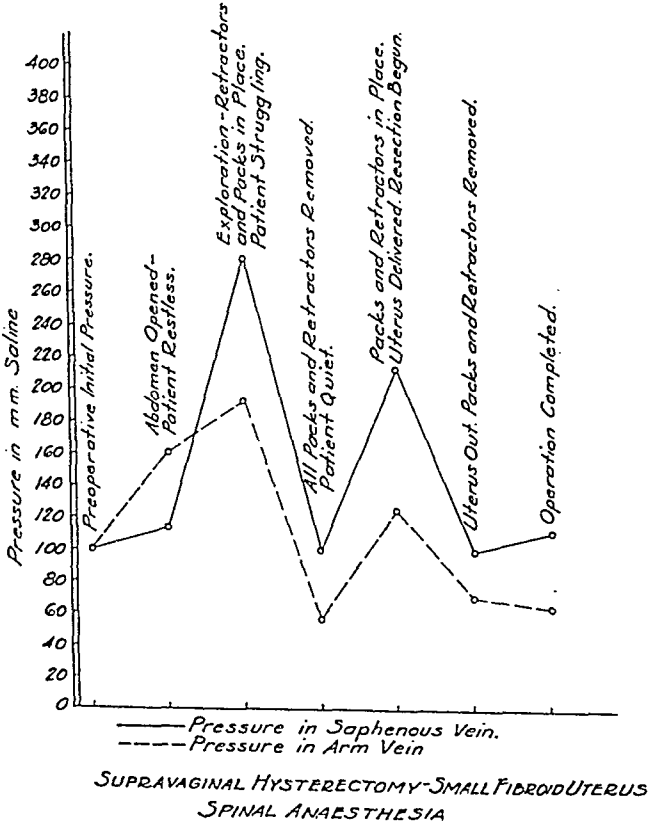


Fig. 2.—Pressure changes in antecubital and saphenous veins during removal of a small fibroid uterus, showing the effect of struggling of the patient upon the antecubital pressure.

The next step in the operative procedures was that of exploring the abdominal cavity and its organs. As soon as any pressure was applied, either by retractors pulling on the walls of the incision or by placing packs or passing the hand inside the abdomen, there was an immediate disturbance of the pressure in the saphenous vein. The pressure in the antecubital vein remained stationary. The stretching of the incision resulted in a prompt elevation of the saphenous pressure. The placing of the surgeon's hand in the abdomen caused a further rise in the pres-

sure, particularly when the upper abdomen was explored. The placing of packs, of course, had the same effect as exploration, and the elevation was persistent as long as the packs remained in place. Compression applied directly over the inferior vena cava produced an even greater rise in the saphenous pressure. Another interesting point was that tugging on the loops of the bowel caused an immediate elevation of the saphenous pressure, even as great as placing packs inside the abdomen. By removing all packs and retractors, tugging on the mesentery still produced this rise. When all retractors and packs were removed and all manipulation stopped, the saphenous pressure rapidly returned to or very near its initial base line (Figs. 4 and 5).

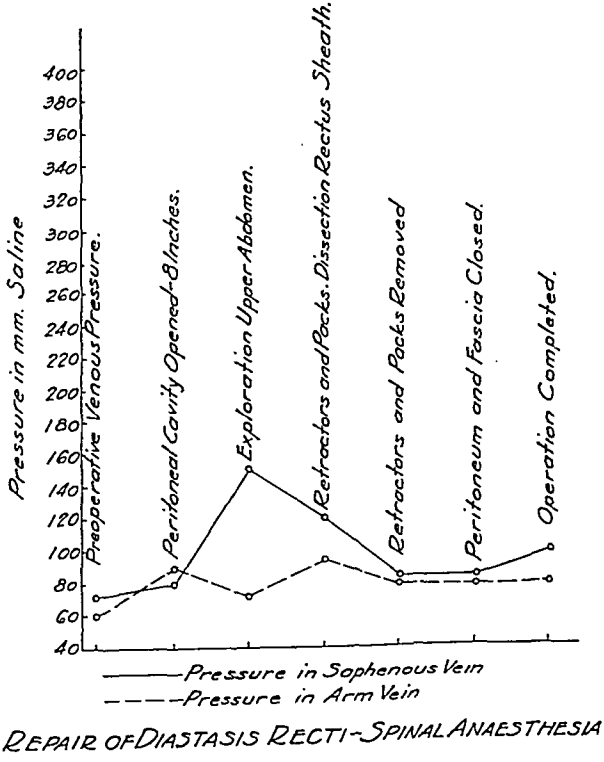


Fig. 3.—Venous pressure changes during the repair of diastasis recti, showing slight effect of opening the peritoneal cavity.

The degree of elevation caused by these various manipulations varied to some extent in the different cases, but in all the trend was the same. The pressure in the antecubital vein was unaffected by any of these maneuvers. In several instances the patient evidenced some pain during the exploration and made struggling motions with the arms and upper part of the body. During such a period there was a prompt rise of the antecubital venous pressure. On relaxation the pressure returned to the normal level, although the exploration continued. The

greatest rise of the saphenous pressure at any time was 205 mm. of saline solution. It seems unlikely that a change of this degree in the venous pressure is sufficient in itself to produce any physical damage that might lead to venous thrombosis.

Three of this series of ten cases deserve special comment, two because of abnormal elevations of the saphenous venous pressures and the third because surgical shock occurred during operation with a striking effect upon the general venous pressure.

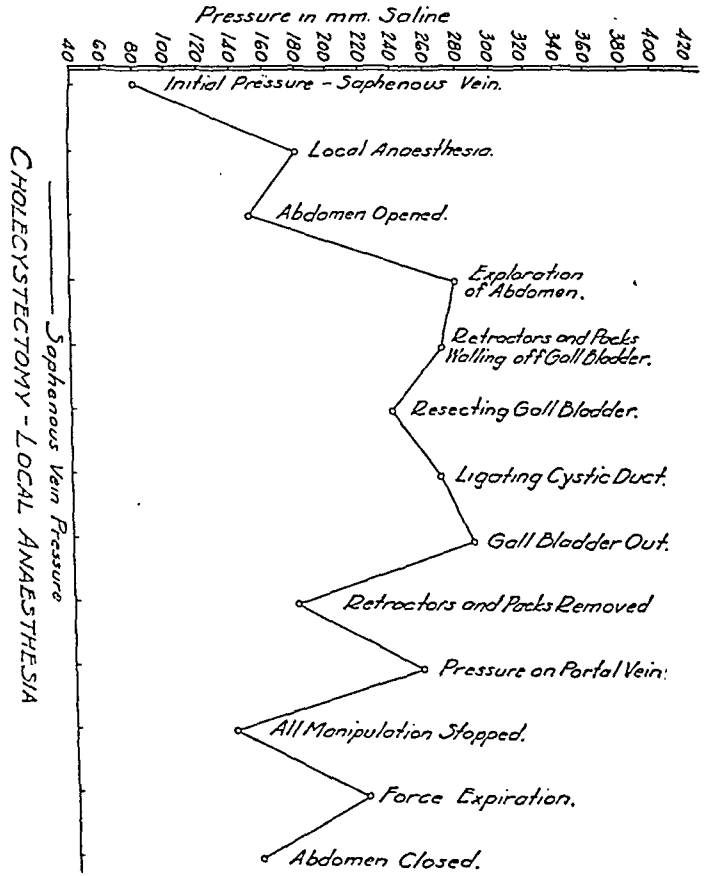


FIG. 4.—Changes in the saphenous pressure during removal of gall bladder under local anesthesia, showing the marked effect of exploration and introduction of packs.

Case 3 (Table I) was one in which hysterectomy was performed for a very large fibroid tumor of the uterus. The pressure in the saphenous vein before operation was 240 mm. of saline solution. The usual effects of the operative maneuvers upon the saphenous pressure were obtained, but at no time did it fall below the initial level. The reading obtained immediately postoperative was 270 mm. of saline solution.

Case 5 (Table I, Fig. 6) was one of idiopathic hemolytic icterus in which removal of a 10-pound spleen was performed. The initial pressure

sure, particularly when the upper abdomen was explored. The placing of packs, of course, had the same effect as exploration, and the elevation was persistent as long as the packs remained in place. Compression applied directly over the inferior vena cava produced an even greater rise in the saphenous pressure. Another interesting point was that tugging on the loops of the bowel caused an immediate elevation of the saphenous pressure, even as great as placing packs inside the abdomen. By removing all packs and retractors, tugging on the mesentery still produced this rise. When all retractors and packs were removed and all manipulation stopped, the saphenous pressure rapidly returned to or very near its initial base line (Figs. 4 and 5).

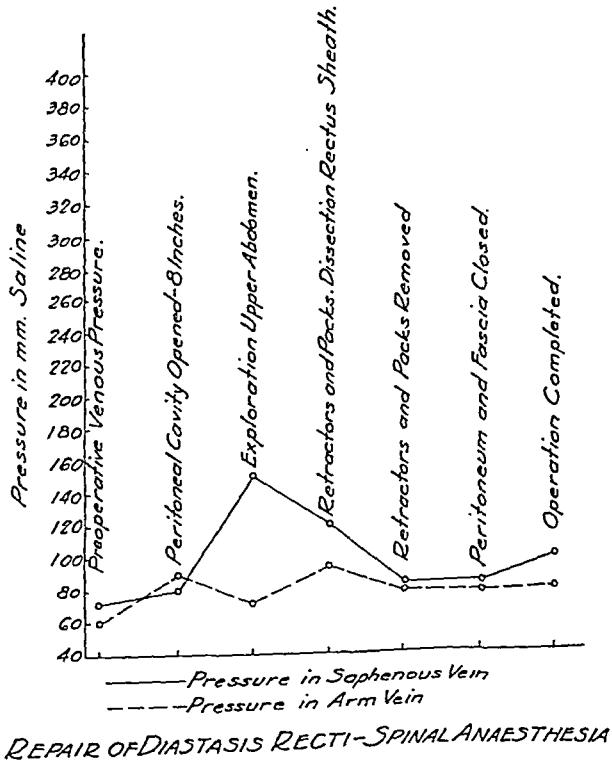


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The degree of elevation caused by these various manipulations varied to some extent in the different cases, but in all the trend was the same. The pressure in the antecubital vein was unaffected by any of these maneuvers. In several instances the patient evidenced some pain during the exploration and made struggling motions with the arms and upper part of the body. During such a period there was a prompt rise of the antecubital venous pressure. On relaxation the pressure returned to the normal level, although the exploration continued. The

The fact that the venous pressure remained high in the saphenous vein of each of the two cases cited indicates that there was persistent partial obstruction of the veins. This in turn means a persistent slowing of the venous blood flow which may offer a partial explanation of the observation that venous thrombosis occurs more frequently after the removal of large intra-abdominal tumors than after other abdominal operations. These studies should be pursued in order to discover a complete and logical explanation.

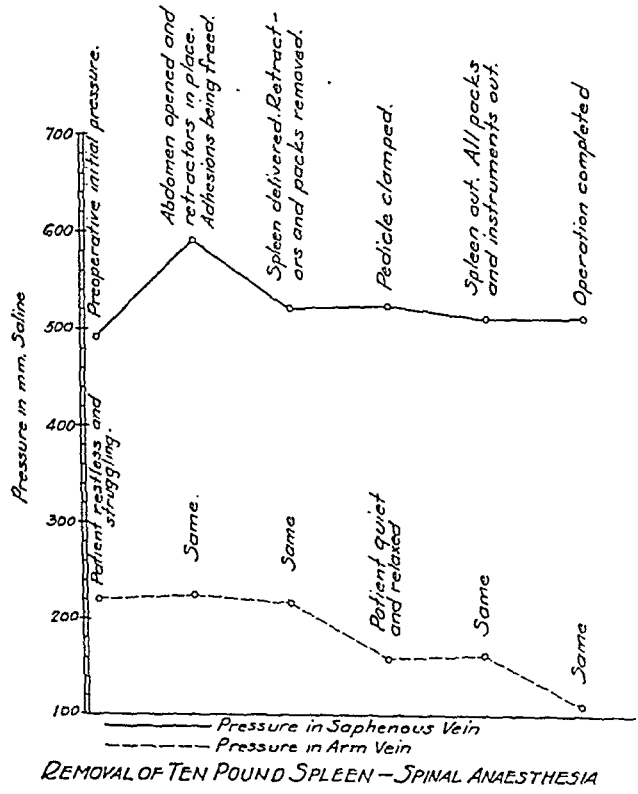


Fig. 6.—Marked elevation of saphenous pressure before operation. Persistent elevation after removal of very large spleen.

Case 10 (Table I) was one of benign stricture of the rectum for which colostomy was performed under spinal anesthesia. In this case the initial arterial blood pressure was 138 systolic, 98 diastolic. The initial pressure in the saphenous vein was 80 mm. of saline solution. During the operative maneuvers the changes in venous pressure were similar to those observed in the other cases until the patient began to manifest signs of mild surgical shock. Within ten minutes the arterial blood pressure fell from 150 systolic and 100 diastolic to 100 systolic and 60 diastolic, and a few minutes later it was found that the saphenous pressure had fallen from 140 mm. to 70 mm. The signs of shock lasted for ten minutes, during which the usual operative procedures, such as

in the saphenous vein was 480 mm. There were the usual fluctuations in venous pressure during the operation, but the postoperative saphenous pressure remained high (470 mm.).

In these two cases it appeared that the pressures in the saphenous veins were high before operation because of the presence of very large intra-abdominal tumors. It is interesting to note that the usual fluctuations in saphenous venous pressure attended the operative maneuvers. It is difficult to find an explanation for the fact that the saphenous pressure remained quite high after removal of the apparent cause for the original retardation of venous flow. That the persistent elevation was not a part of a generalized increase in venous pressure (e.g., heart

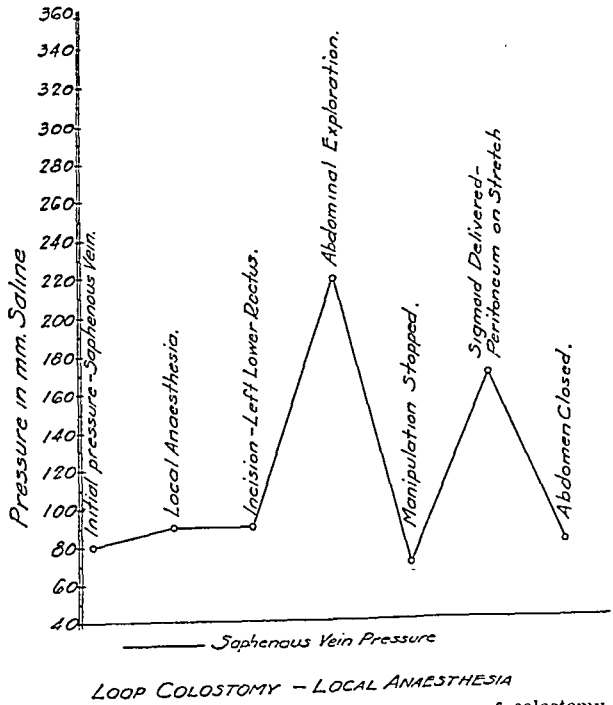


Fig. 5.—Saphenous pressure changes during performance of colostomy under local anesthesia, showing marked rise during exploration and prompt fall on stopping the manipulation.

failure) is demonstrated by the normal findings in the upper extremities at the conclusion of operative procedures, when the patient was relaxed. It is probable that, due to prolonged retardation of the flow of blood from the lower extremities, some physical change took place in the veins and was not readjusted, at least immediately, by removal of the tumors. It is remotely possible that the persistent elevation of saphenous pressure was due to venous spasm, although it seems unlikely that such a mechanism should have been active only in these two cases, the conduct of which was no different otherwise from the other eight cases.

THE METEOROLOGIC FACTOR IN PULMONARY EMBOLISM

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IN A RECENT study of 100 cases of pulmonary embolism the precipitating factors producing this vascular accident were discussed.[1] In 70 per cent of the cases no obvious cause was found to explain the mobilization of the clot. (Table I.) Because of the interest of one of us (W. F. P.) in the modifying effects of meteorologic environment on the patient,[2] this material was subjected to a statistical analysis from this angle. It has been shown previously that the blood picture (red blood corpuscles, leucocytes, platelets), as well as the composition of the blood (pH, K/Ca ratio, protein, fibrinogen, sugar), the clotting mechanism, and the sedimentation rate, all reveal continuous fluctuations from day to day in a manner that indicates an influence of the air mass over the patient's "stable" laboratory findings.[3]

TABLE I

PRECIPITATING FACTORS IN PRODUCING EMBOLISM*

	NO. OF PATIENTS
Bowel movement	15
Getting in and out of wheel chair	6
Morning care	3
During or immediately after operation	3
Nausea from smelling ether	1
Insertion of Levine tube	1
Hiccough	1
No obvious cause	70
Total	100

*Notice that in 70 patients no obvious cause for the mobilization of the clot was found.

For many years an inter-relation of thrombosis and embolism with the weather, and particularly with atmospheric disturbance, has been suspected. In the writings of Hippocrates one frequently finds the idea that the human organism is literally a "cosmic resonator" responding with varying intensity to every change in the meteorologic environment.[3] For the vascular tree this means spasm and relaxation, rise and fall in pressure, changes in permeability and velocity of blood flow. The first phase, namely high blood pressure, vascular spasm, decreased permeability, is initiated by the passage of a cold air mass; the second phase follows in the wake of the first as a compensatory

Received for publication, December 28, 1939.

stretching the operative incision, exploration of the abdomen by the surgeon's hand, and tugging on the mesentery, failed to cause the usual rise in saphenous pressure. Administration of epinephrine and physiologic salt solution restored the arterial and venous blood pressures to higher levels, after which the venous pressure again fluctuated normally in response to operative maneuvers.

SUMMARY AND CONCLUSIONS

1. The effects of operative procedures during ten standard abdominal operations upon the blood pressures in the antecubital and saphenous veins are reported.

2. Anesthesia has little direct influence upon the venous pressure except so far as struggling movements of the patient and irregularity of his breathing are permitted or encouraged.

3. Operative manipulations within the abdominal cavity cause an immediate rise in pressure in the saphenous vein without directly affecting the antecubital pressure. The magnitude of this rise is probably not sufficient in itself to evoke a predisposition to venous thrombosis.

4. Two cases are reported in which high pressures in the veins of the lower extremities before operation were unrelieved by removal of very large intra-abdominal tumors. In such cases it may be presumed that a predisposition to venous thrombosis exists.

5. One case is reported in which surgical shock produced a fall in venous pressure.

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as a possible factor in the production of thromboses. The year 1930 is illustrative of the trend that seven out of the ten yearly graphs show (Fig. 1); namely, the freedom from emboli in June and July, with only one embolus in August and the accumulation of these accidents in the months during which barometric pressure (straight line) and temperature (interrupted line) are markedly fluctuating; especially February, March, and October show a massing of emboli (Fig.

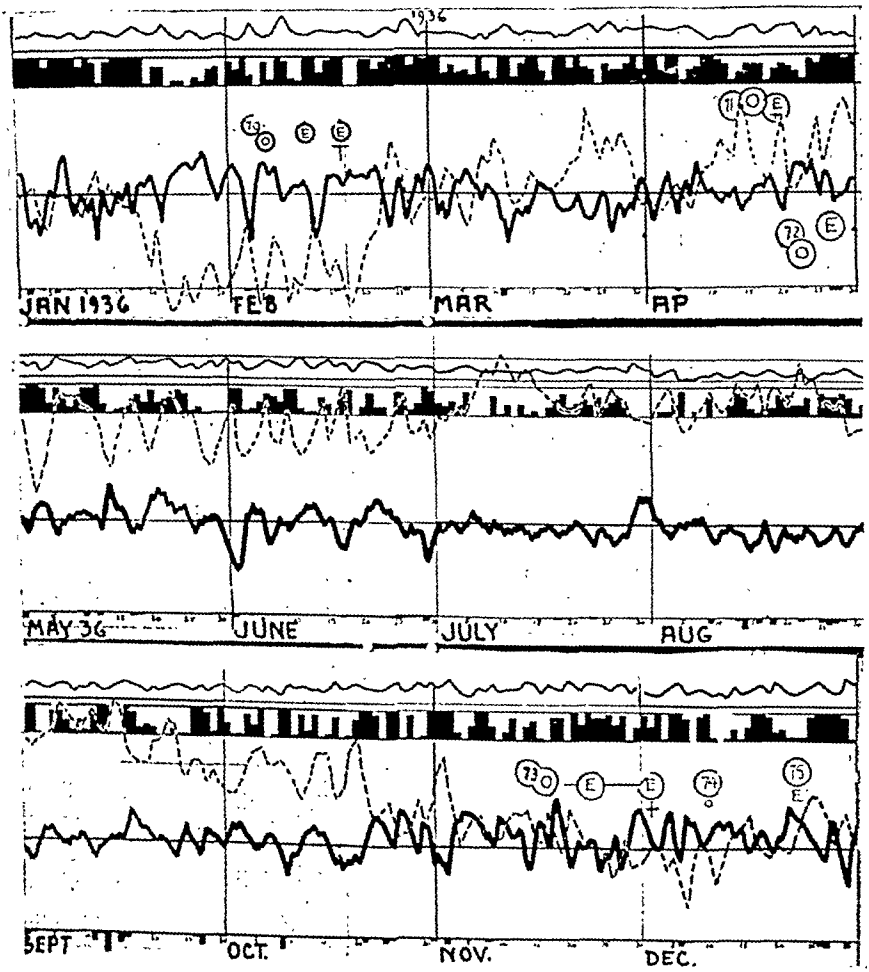


Fig. 2.—Meteorograph of the year 1936. (For key to illustration, see legend to Fig. 1.)

1). In the graphs, to be read from above down, wind, sunshine, barometric pressure, temperature, and precipitation have been recorded. A similar trend is shown in Fig. 2 with February, April, and November being the embolic months; whereas, June, July, and August are free. Three out of the ten graphs, however, do not show such a definite correlation and Fig. 3 is shown as illustrative of this group. In the year 1938, while the marked fluctuation of barometric pressure coin-

phenomenon.[4] That such fluctuations may actually influence the incidence of thromboses and emboli is supported by the fact that thromboses are more frequent in the northern states than in the southern states and also by the greater incidence during the winter months as compared to the summer months. The average incidence of venous lesions in a vital statistical survey was 0.74 per 100,000 population in the northern states as contrasted with 0.41 per 100,000 population in the southern states.[5]

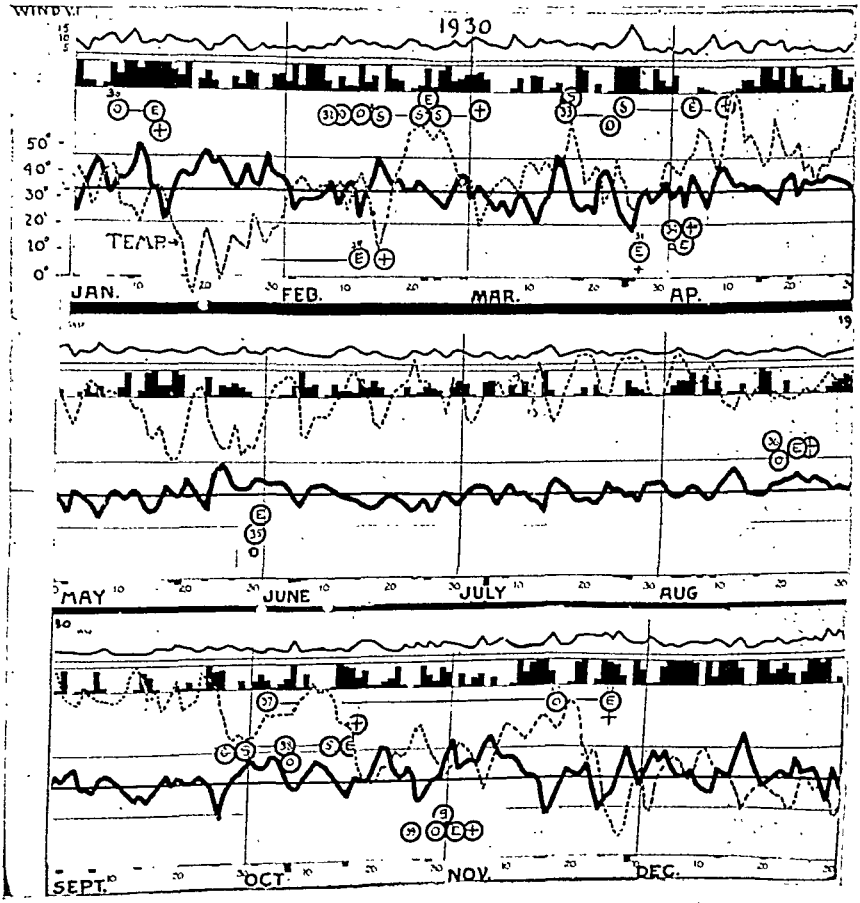


Fig. 1.—Chicago meteorogram for the year 1930. Upper curve, wind velocity in miles per hour; white-black columns, white, percentage of possible sunshine; heavy curved line, barometric pressure; dotted line, mean daily temperature; black columns under date line, precipitation; case number in circles; *O*, operation; *E*, embolism; ±, death; *S*, symptoms.

METHODS OF STUDY

Meteorographs were prepared for the years 1929 to 1938, inclusive, and the occurrence of emboli was plotted into these curves. As many of the emboli were postoperative, the time of operation was also recorded

parts of the year, the material was divided into three sections: (a) January to April, inclusive; (b) May to August, inclusive; and (c) September to December, inclusive.

Fig. 4 shows the averages of the temperature deviations. In all three groups it is seen that the average deviations of temperatures during the five days preceding the occurrence of embolism have considerable variation as contrasted to the relatively stable movements following the occurrence of embolism. The September to December movements appear to be of a different character than the other two groups, bearing out the belief that seasonal differentiation occurs in the reaction to temperature.

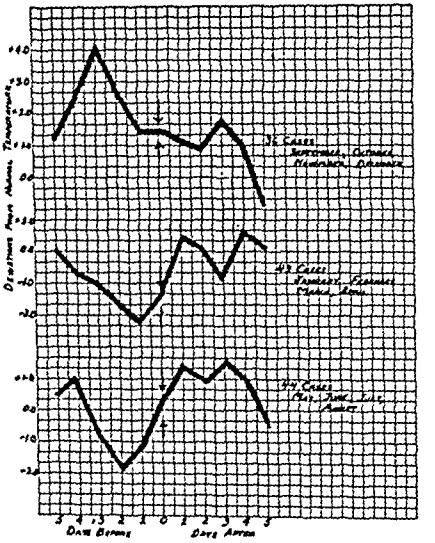


Fig. 4.—The mean deviations from normal temperatures in the fall, winter-spring, and summer seasons, five days before and five days following pulmonary embolism (average of 100 cases). Notice that embolism occurs after an unusual movement of temperature. During September to December a sharp increase followed by a sharp decline in temperature occurs preceding the embolus. During January to April embolism tends to occur from the fifth to the second day preceding its onset; a similar type of movement takes place during the months May to August, but it is not statistically significant.

Several questions arise concerning the validity and the meaning of these averages. Are the differences in temperature from day to day great enough to warrant an opinion that a distinctive movement is taking place, or could these temperature changes be obtained by chance selection under the assumption that the day-to-day movements in temperature and observations on embolism were independent of each other? Secondly, would a random selection of days covering this same period give averages which would describe the same movement in temperature?

The method of analysis of variance proposed by Fisher[6] will give us an answer to the first question. We will attempt to discover whether the variance in temperature (deviations from normal) between the

cided with pulmonary emboli from February to May, Case 93 died of a fatal embolus in August, during comparatively stable barometric pressures.*

A scrutiny of the ten yearly graphs reveals that emboli are most frequent from the January to May and the October-November periods.

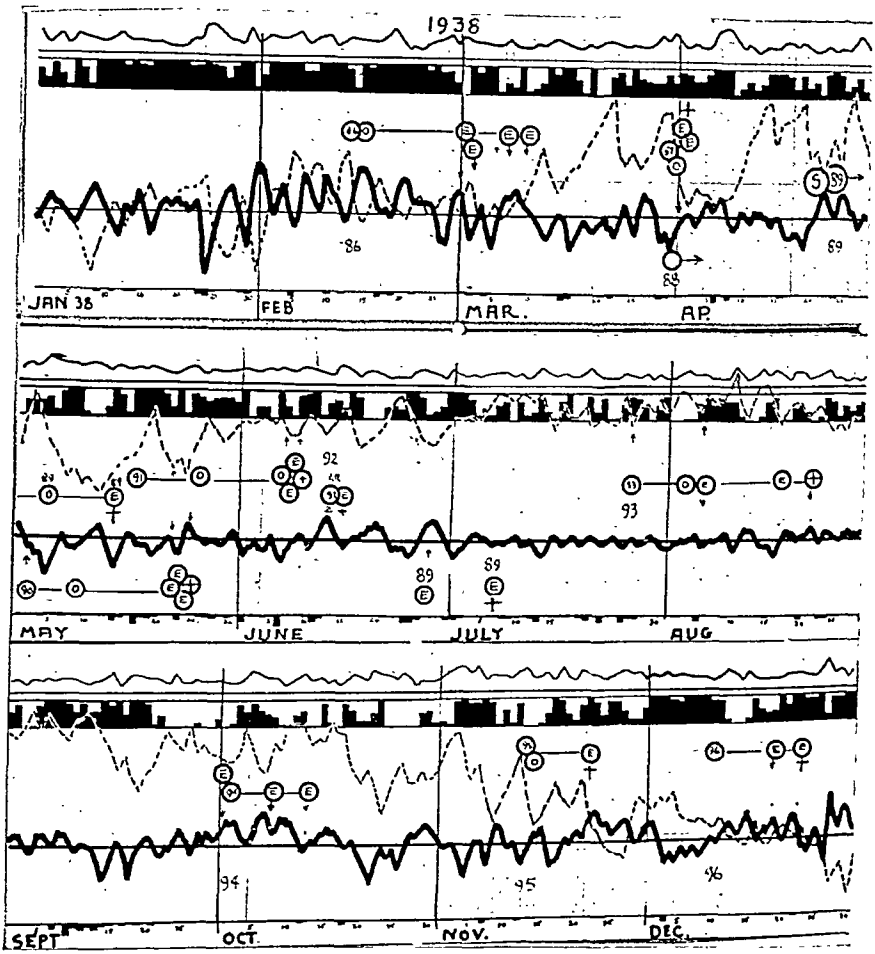


Fig. 3.—Meteorograph of the year 1938. (For key to illustration, see legend to Fig. 1.)

The deviations of mean temperature from normal for the five days preceding and the five days following the occurrence of embolism, including the day of occurrence, were also considered. Because of the belief that the reaction to temperature may vary during the different

*The embolism actually occurred at a time when there was almost an inch of rain on the fifth of the month and then the next embolic process occurred when the barometer turned from the low of approximately 29.75 to a high of 30.15. Then followed rain on the twentieth and death occurred, again with the barometric crest. On the whole both of the embolic processes as well as death were associated with considerable environmental disturbance and in between the two emboli the highest temperature of the year was registered which must have reached well into the nineties.

The above material indicates that for two of the periods we must conclude that (1) a significant series of average temperature deviations have been found and (2) the different observations supplement each other and are not of the type expected by random sampling. During the period May to August, variations which were not significant were observed. This may be due to the shifting of the temperature picture from the first part of the year to the last part of the year.

The analysis has been based upon the assumption that the deviations of temperature data from normal belong to a random series—no intercorrelation between successive days. This probably is not entirely true; and in order to perform another test dealing with the movement of the temperature in the neighborhood of the occurrence of embolism, a comparison was made with the temperature of five days preceding and following days which had been selected at random. The random selection covered approximately the same period as the 100 cases observed. In Table V will be found the average temperature deviations of the random days compared to the average deviations of temperature of days related to the embolism cases.

TABLE V

AVERAGES OF DEVIATIONS FROM NORMAL TEMPERATURES

DAY	JANUARY-APRIL		MAY-AUGUST		SEPTEMBER-DECEMBER	
	EMBOLISM	RANDOM	EMBOLISM	RANDOM	EMBOLISM	RANDOM
5th before	+0.2	+2.8	+0.5	−2.2	+1.2	+0.1
4th before	−0.6	+2.6	+1.0	−0.6	+2.4	+0.5
3rd before	−1.0	+3.6	−0.8	−0.2	+4.1	−0.1
2nd before	−1.7	+2.6	−1.9	−1.5	+2.6	−0.4
1st before	−2.2	+0.6	−1.1	+2.4	+1.5	−0.6
0	−1.3	+0.3	+0.3	+2.8	+1.5	−0.9
1st after	+0.3	+2.0	+1.4	+3.0	+1.2	+0.2
2nd after	−0.2	+0.9	+0.9	+3.7	+0.8	−0.1
3rd after	−0.8	+2.4	+1.5	+3.6	+1.7	−0.8
4th after	+0.7	+4.2	+1.9	+1.2	+1.0	+0.4
5th after	+0.1	+1.7	−0.5	−0.6	−0.7	+1.9

In the actual comparison only six days (the five days prior to the occurrence and the day of occurrence) were studied, as it is only the large movement in temperature prior to the incidence of embolism which interests us. Adjusting the series so that the means are equal, Chi-square P test was employed. The Chi-square test indicates that the differences between the series were great enough to justify an opinion that the series of temperature deviations based upon the date of embolism was formed in a fashion which was not random. Chi-square was: (1) January to April, 19.41; P, less than 0.01; (2) May to August, 8.69; P, 0.07; (3) September to December, 44.39; P, less than 0.01.

It appears that the statistics collected on embolism and temperature of neighboring days indicate that embolism generally occurs after an unusual movement of temperature of rather sizable variability. The

days (fifth, fourth, third, etc.) is significantly greater than the variance of temperature for a given day, say the fifth. The necessary information for the period, January to April, is summarized in Table II.

TABLE II

ANALYSIS OF VARIANCE (JANUARY-APRIL)

SOURCE OF VARIATION	NO. OF DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	472	42,262.56	
Between days	10	2,252.10	225.21
Within groups	462	40,010.00	86.60
F, 2.60; 5% value of F, 1.86; 1% value of F, 2.41*			

*F is defined as the ratio of two independent tests of the variance of a statistical population; the exact sampling distribution of F has been discovered by Fisher.[6] In this problem two estimates of variance are provided by (1) the variance of the means of the temperature deviations of the eleven days and (2) the sum of the variances of the temperature deviations of each day. If the F observed is unlikely to occur as given by the sampling distribution of F, it is necessary to conclude that significant variation occurs in the means, as compared to the variations within each day, and that the movement of the means in significant. The 5 per cent and 1 per cent points are considered critical levels of significance.

It is seen that the probability of obtaining an F (see footnote, Table II) as observed is less than 1 out of 100, and it can be said that the variations in the average temperature deviations are significantly different from each other. Table III has the same material summarized for May to August. It is seen that the means for the May to August period are not significantly different for the observed F is less than the 5 per cent F obtained by random sampling.

TABLE III

ANALYSIS OF VARIANCE (MAY-AUGUST)

SOURCE OF VARIATION	NO. OF DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	483	27,504.49	
Between days	10	556.79	55.679
Within groups	473	26,947.70	56.970
F, 0.98; 5% F, 1.86; 1% F, 2.41			

Again the summarized material is presented in Table IV for the months September to December. The variation from day to day is then significant for the observed F is obtained less than 1 per cent of time by random sampling.

TABLE IV

ANALYSIS OF VARIANCE (SEPTEMBER-DECEMBER)

SOURCE OF VARIATION	NO. OF DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE
Total	395	47,894.00	
Between days	10	3,781.17	378.12
Within groups	385	44,112.80	114.58
F, 3.300; 5% F, 1.87; 1% F, 2.39			

study many years back. Therefore, its emphasis is not without proof. In the individual case the reaction of the body to vasomotor stimuli is occasionally striking.

The time is perhaps not all too distant when stable temperature, humidity, and barometric pressure may surround the postoperative patient. Until that is possible a good alkaline reserve, a toning down of autonomic reflexes with atropine and phenobarbital, and an inhibition of vasospastic phenomena with papaverine may place the patient in a favorable internal milieu and free him from some of the influences of external environment.[1]

SUMMARY

The occurrence of 100 cases of pulmonary embolism has been correlated with meteorologic charts and with fluctuations of environmental temperatures. It was found that during the spring and fall periods, which showed marked barometric and thermal fluctuations, actually more emboli occurred and that the summer months were comparatively exempt. The effect of marked deviations from the mean temperature, proved statistically, also seemed to bear influence on the mobilization of blood clots. It has been emphasized that many other predisposing and precipitating factors are known to operate in cases of embolism and that the weather factor is one which readily lends itself to registration. The maintenance of a steady external environment may be of benefit to the patient threatened by embolism.

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nature of the movement of temperature varies during the year. During January to April, embolism tends to occur after a drop in the temperature from the fifth day preceding occurrence to the second day preceding the occurrence, rising immediately until the day of incidence. During the months May to August a similar type of movement takes place but cannot be considered statistically significant without further material. During September to December an opposite type of movement in temperature takes place, first a sharp increase in temperature for several days, followed by a sharp decline until the day of incidence of the cases.

DISCUSSION

The study of these graphs and others which lack of space does not permit us to present indicates that meteorologic factors and the process of embolism may be correlated. Obviously a great many conditioning factors are at play in the formation of thrombosis and embolism. An excellent summary of the predisposing and precipitating factors has been given by Ochsner and De Bakey.[5] The age of the patient, his cardiovascular status, constitutional diathesis, obesity, debility, infection, trauma, the anesthetic, the severity of operation, and the postoperative course are all factors, the importance of which is statistically proved. It is surprising that, in spite of the multitude of these factors, certain correlations between the weather and embolism can be demonstrated at all. For this reason emboli will naturally occur even during even temperature and barometric curves; it is our conviction, however, that, other factors being equal, a sudden meteorologic change is capable of precipitating these vascular changes.

It seems as if the embolic process would follow a cold wave. In the fall period, two days before the embolism, a steep decline in temperature occurred; one might even speculate as to the importance of the rise in the temperature previous to the fall as being a thrombogenic factor, but there is little proof as yet for this assumption. In the winter-spring period, a four-day fall in temperature has preceded the embolism which has occurred with the change to warmer weather. In the summer period the same fall followed by a rise occurs. On observation of the three periods it almost seems as if the same pattern were present except that the vascular reaction is delayed in the spring and even more so in the summer because of the higher average temperatures. Thus in the fall period the average temperature was 47° when the emboli occurred, as compared with 65° when emboli occurred in the summer. The analogy with delayed reflex vasoconstrictions occurring at higher environmental temperatures comes to mind.

These conclusions are derived from mean values and therefore are merely indicative of certain trends. We do not wish to imply that the weather factor is more important than any of the others enumerated above, but this factor can be readily registered and is capable of

study many years back. Therefore, its emphasis is not without proof. In the individual case the reaction of the body to vasomotor stimuli is occasionally striking.

The time is perhaps not all too distant when stable temperature, humidity, and barometric pressure may surround the postoperative patient. Until that is possible a good alkaline reserve, a toning down of autonomic reflexes with atropine and phenobarbital, and an inhibition of vasospastic phenomena with papaverine may place the patient in a favorable internal milieu and free him from some of the influences of external environment.[1]

SUMMARY

The occurrence of 100 cases of pulmonary embolism has been correlated with meteorologic charts and with fluctuations of environmental temperatures. It was found that during the spring and fall periods, which showed marked barometric and thermal fluctuations, actually more emboli occurred and that the summer months were comparatively exempt. The effect of marked deviations from the mean temperature, proved statistically, also seemed to bear influence on the mobilization of blood clots. It has been emphasized that many other predisposing and precipitating factors are known to operate in cases of embolism and that the weather factor is one which readily lends itself to registration. The maintenance of a steady external environment may be of benefit to the patient threatened by embolism.

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FURTHER REPORT ON THE TREATMENT OF THE UNDESCENDED TESTES BY HORMONAL THERAPY AT THE UNIVERSITY OF MINNESOTA HOSPITALS

A Discussion of Spontaneous Descent of the Testis and an Evaluation of Endocrine Therapy in Cryptorchidism

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THE treatment of undescended testes by gonadotropic substances is generally recognized, but the results of treatment are so varied that a critical review of this form of therapy is indicated.

Bigler, Hardy and Scott in a review of the literature (1938) report the results of nineteen investigators who found that descent occurred in over 75 per cent of 262 patients with undescended testes treated with pituitary or pituitary-like extracts. In their own series of 71 boys with 91 ectopic testes treated with antuitrin-S, descent of the gonad into the scrotum was permanent in 45 per cent of cases. They found that descent occurs in most cases when about 4,000 units have been injected. Nixon in an excellent review of the literature also collected reports of 388 boys with 574 retained testes who were treated with intramuscular injections of various gonadotropic substances. In most instances extracts of pregnancy urine were used. As much as 40,000 units and as little as 100 rat units have been reported to produce testicular descent. Injections have been given daily for a limited period, or two or three times a week for an indefinite period. The percentage of successful results varied from 100 to 19 per cent. In the entire group of reported cases, 59 per cent of the gonads were said to have descended after treatment. Approximately one-third more of the patients with bilateral retention responded to therapy than those with a unilateral condition. Nixon treated 59 boys with 76 undescended testes; of these 25, or 33 per cent, descended. A course of treatment consisted of intramuscular administration of 250 rat units of gonadotropic substance three times each week until thirty injections had been given, a total of 7,500 rat units. If after ten weeks of treatment the testes had not descended to the normal low scrotal position, the patient was given a rest for at least three months before a second course of gonadotropic substance was instituted.

Thompson and Heckel analyzed the reports of twenty-seven observers. Of 860 undescended testes in 579 patients, the condition was bilateral in 281 and unilateral in 298. Of all the undescended testes treated by hormonal therapy, 524, or 61 per cent, descended. The successful results

Received for publication, November 24, 1939.

may be divided according to the original position as follows: intra-abdominal, descent reported in 83 of 150 cases, or 55 per cent; inguinal, descent reported in 172 of 298 cases, or 58 per cent; in the upper part of the scrotum, descent reported in 15 of 17 cases, or 88 per cent; and location unstated, descent reported in 254 of 395 cases, or 64 per cent. In Thompson and Heckel's own series of 50 retained gonads in 38 patients, only 20 per cent descended following endocrine therapy. Of the patients under 16 years of age, descent occurred in only 27 per cent.

Mimpriss has reported descent in only 29 per cent of cryptorchids treated by gonadotropic substance. Zelson found that, of 26 boys with 34 undescended testes, complete descent occurred in 8 cases, or 31 per cent. In a previous report the results of treatment of ectopic testes by gonadotropic substance at the University of Minnesota Hospitals were reviewed: In a series of 36 patients with ectopy treated with anterior pituitary-like substances, degrees of descent were noted in 6 (16 per cent). In 4 descent was complete.

One of the purposes of this paper is to report another series of 32 patients with 36 undescended testes treated at the University of Minnesota Hospitals. The ages ranged from 6 to 20 years. In 4 instances the ectopy was bilateral. The substances used were APL (Ayerst), special strength (500 rat units per c.c.), and antuitrin-S (Parke-Davis) (100 rat units per c.c.). The following methods were used in giving the anterior pituitary-like substance:

1. APL (Ayerst), 500 units intramuscularly every day for ten injections (8 patients).
2. APL (Ayerst), 500 units intramuscularly every other day for ten injections (8 patients).
3. APL (Ayerst), 250 units every other day for fifteen injections (8 patients).
4. Antuitrin-S (Parke-Davis), 250 units intramuscularly every other day for twenty injections (8 patients).

It will be noted that the dosages are much higher than those reported in the previous communication.

If no results were obtained following the first course of treatment, the patient was given a rest for one month and a subsequent course suggested. If no results were obtained after the second course of treatment, the patient was allowed to wait three to six months to see if descent of the testis would occur; if there had been no descent at the end of this time, an orchiopexy was advised.

Results.—Of the 32 patients with 36 undescended testes treated by anterior pituitary-like substances, descent occurred in 6 patients and in 7 ectopic testes (1 bilateral case). This makes an incidence of descent in 18.7 per cent of patients and 19.4 per cent of cases. There was no uniformity in the dosage or length of treatment in the suc-

TABLE I

NO.	HOSPITAL NO.	AGE	UNDESCENDED TESTIS		DOSE	RESULT	COMMENT
			SIDE	POSITION			
1	681623	11 yr.	Bilateral	Inguinal	500 units APL (Ayerst) every day for 10 injections. Total 5,000 units	Complete descent	
2	677218	20 yr.	Left	Inguinal	First course 2/4/39, 5,000 units; 500 units APL (Ayerst) every other day for 10 injections. Another course 3/17/39, 5,000 units. Another course 4/14/39. Total, 15,000 units.	Upper scrotal	
3	683836	7 yr.	Right	Abdominal	500 units APL (Ayerst) every other day for 7 injections. Total, 3,500 units	Complete descent	
4	667771	8 yr.	Left	Inguinal	250 units antuitrin-S every other day after 15 injections. Total, 3,750 units	Complete	
5	668764	13 yr.	Right	Inguinal	250 units APL (Ayerst) every other day for 15 injections. Total 3,750 units. Second course 5,000 units. Total, 8,750 units	Went to scrotum but later attained high scrotal	Orchiopexy 1/25/39
6	Pvt. Pt.	9 yr.	Right	Abdominal	200 units antuitrin-S every day for 20 injections. Total, 4,000 units	Complete descent	

cessful cases (Table 1). In the successfully treated cases, the gonad was inguinally retained 3 times and abdominal in position twice in the unilateral cases; in the 1 bilateral case, the original position of both gonads was inguinal. In 1 instance (Case 2) the testis attained a high scrotal position after treatment. In another, Case 5, the testis descended to a low scrotal position but later ascended remaining high in the scrotum. Complete descent was obtained in 4 patients and 5 cases of undescended testes. Similar to the previous series, all the cases had been followed six months or longer.

Of the 26 patients in which there was failure of descent following endocrine therapy, the position of the gonad was inguinal 18 times and abdominal in 8 instances. All the patients have received at least 3,750 units of anterior pituitary-like substance during the course of treatment. Five patients with inguinally retained testes, all under 12 years of age except one boy who was 17 years, received two courses of hormonal therapy consisting of 500 units of APL (Ayerst) intramuscularly every day for ten injections (total 10,000 units over a period of three months). Six patients, 5 with unilaterally retained testes and 1 with an abdominally ectopic gonad, were treated with two courses of APL (Ayerst), 250 units every other day for fifteen injections (total 7,500 units). No descent occurred on observing the patients over a period of six months. Another boy, 9 years old, with inguinal maldescent, received a total of 15,000 units of antuitrin-S over a four-and-one-half-month period without descent of the testis. No untoward reactions have resulted from the use of the hormone in the doses mentioned; certainly excessive genital growth has not been observed.

SPONTANEOUS DESCENT OF THE UNDESCENDED TESTIS

It is still an important question: What percentage of undescended testes descend spontaneously? If the majority of ectopic testes will eventually descend of their own accord, as some investigators claim, the value of any kind of therapy is questionable.

There are several reports of spontaneous descent of the retained testes in the literature. Some investigators maintain that all retained testes will eventually descend, while others believe that spontaneous descent is a rare occurrence. The statistics are colored by the type and location of the retained gonad and the age of the patient, as well as the experience of the investigator in examining such patients. It is our opinion that those claiming that the undescended testes rarely descend of their own accord are usually dealing with cases of testes retained because of mechanical obstruction to descent, while those that say that most cases of ectopic gonads will descend spontaneously if left alone undoubtedly are including cases of physiologic ectopy (to be discussed later).

Drake has maintained for some time that most cryptorchid glands will descend spontaneously at puberty. Williams and Johnson also seem to be of this opinion. Williams examined the records of 2,104 boys. Of these, 38 had one testicle undescended (1.8 per cent) and 21 had both testicles retained (1 per cent). The ages ranged from 8 to 18 years. Of 27 boys in whom only one testicle was ectopic and no complicating factor was present, there was natural descent in 24 (87 per cent). Of 16 boys in whom both testicles were undescended and no complicating factor was present, there was natural descent of both in 14 (87 per cent). The patients were observed up to the age of 16 years and a few up to 18 years.

The study by Johnson comprised 544 cases of undescended testes observed from 1931 to 1937 inclusive. These cases were found during the routine examination of 31,609 boys, an incidence of 1.72 per cent. In at least 313 of these 544 cases of ectopy, spontaneous descent of the gonad occurred. The boys' ages ranged from 7 to 17 years.

The incidence of undescended testes in adults, according to the Draft Statistics of the War Department for the World War, was 3.1 per 1,000 men examined, or 0.3 per cent. The finding of cryptorchidism in adult men seems irrefutable evidence that all undescended testes do not descend spontaneously. According to Johnson, Williams, and Drake, the incidence of cryptorchidism in younger boys is 1.7 to 4.2 per cent. Apparently the incidence of ectopy is much less after puberty than before that period. This may mean that the hormonal changes incident to puberty produce descent in a large percentage of cases.

However, another explanation of this difference in the incidence of cryptorchidism in the prepubertal and postpubertal periods may be the inclusion in the former group of a large number of testes of the migratory or retractile type (physiologic ectopy, pseudocryptorchidism, or ectopy en retour). True undescended testes are those anatomically retained by mechanical obstructions to descent. The criteria for differentiating between true undescended testis and pseudocryptorchidism have been elaborated by Thompson and Heckel, Hamilton, and Rea, and will not be discussed in this paper. Thompson and Heckel and Bevan state that a large number of patients referred to them for treatment of undescended testes really have pseudocryptorchidism; in Bevan's experience about one-third of the patients with supposedly retained testes are of this type. It is my experience and that of other observers (Bevan) that many cases of pseudocryptorchidism spontaneously descend at puberty.

It would be interesting to know what the difference in the incidence of cryptorchidism in the prepubertal and postpubertal age group would be if the migratory testes were carefully excluded. Unless this is known, statistics concerning spontaneous descent of retained

testes are of little value. Theoretically, and from the experience of this clinic, spontaneous descent of a testis retained by mechanical factors probably never occurs. It seems doubtful, also, if hormonal therapy is of much value in causing descent in these cases.

AN EVALUATION OF THE ROLE OF ENDOCRINE THERAPY IN CAUSING DESCENT OF THE TESTES

Engle was the first to study the effects of injecting water-soluble extracts of the anterior lobe of the pituitary gland on descent of the testes of immature monkeys (macaques). Normally the testes of the male macaque are descended at birth, but shortly thereafter they ascend into the inguinal ring. Not until the third or fifth year do the testes descend again permanently. Engle found that pituitary extracts caused precocious descent of the testes of immature macaques.

Thompson and Hooker wonder if the percentage of patients showing descent spontaneously at puberty would be about the same as that following the use of anterior pituitary principle before puberty. Thus, as a result of hormonal therapy, descent of the testis would be obtained only in those cases which would descend normally at puberty. If no more is accomplished by endocrine therapy in young boys with undescended testes than is accomplished by natural processes at a later age, it may be questioned if the treatment is worth while.

Mimpriss believes that any ectopic testis that would descend as development increases can be brought down by hormonal therapy if (a) the dosage is adequate to stimulate sufficient growth of the reproductive system and (b) no mechanical obstruction to descent of the testis is present. He states that the retained testis which is not mechanically retained is only awaiting an adequate state of development before the scrotal position is attained. Mimpriss classifies cryptorchid children by noting (1) the general appearance of the child, (2) development of the genitals, and (3) the situation and mobility of the testis. He further states that it is in the child with cryptorchidism and hypogenitalism that hormonal therapy is most effective. The clinical studies of Shapiro, Sexton, Spence and Brown, Dorff, and Rubinstein would tend to bear out this statement.

The chief value of treatment by gonadotropic substances would seem to be in distinguishing between those cases in which descent is prevented by anatomic factors and those in which it is not. Granted that an unknown number of retained testes will descend spontaneously, this descent should have occurred by puberty or by the addition of extrahormonal stimulation. The practice of waiting until the patient is 18 to 20 years of age to see if the testes will descend of their own accord is not justified, knowing from experimental and clinical data how atrophic these organs become when left in an aberrant position

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then (Wangensteen) and since it is possible that spontaneous descent may occur. A course of endocrine therapy should be given first to see if the additional hormonal stimulus will cause the gonad to descend into the scrotum. If no results are obtained, an orchiopexy should be performed.

From our experience, spontaneous descent or descent following the use of gonadotropic substance in cases of true undescended testis is a rare occurrence. At this clinic every case of true undescended testis upon which an orchiopexy has been performed has shown evidence of mechanical arrest to descent of the gonad.

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It has been the practice at this clinic to wait until puberty before treating uncomplicated cases of retained testes. A course of hormonal therapy is given first. The dosage and length of treatment with anterior pituitary-like substance are quite variable in the cases reported in the literature. There is no correlation of these factors in the successfully and unsuccessfully treated cases (Thompson and Heckel). Experimentally, while gonadotropic hormones have little effect on the mature male, there is clinical and experimental evidence that these substances greatly increase the growth of the reproductive system of the immature male (Dorff). From the experience at this clinic, however, the danger of precocious puberty is more apparent than real following the use of gonadotropic substance. If the patient is carefully watched and not treated by high dosages, excessive genital development can be avoided.

At present in this clinic, anterior pituitary-like substance in doses of 500 rat units per c.c. is injected every day or every other day for ten injections in cases of ectopy. If no results are obtained, the patient is given one month's rest and then a similar course of therapy instituted. If no results are obvious, the patient is allowed a rest of three to six months, and an orchiopexy is performed. No untoward effects from the use of gonadotropic substance have been observed in the doses used. It is interesting to note that, in every case upon which an orchiopexy has been performed at this clinic, evidence of mechanical obstruction to descent of the testis has been present.

CONCLUSIONS

In spite of reports from other clinics showing a high incidence of successful results following the treatment of undescended testis with gonadotropic substance, the results obtained by Thompson and Heckel, Mimpriss, and this clinic have been less encouraging. In two series of retained testes treated to date by gonadotropic substances at the University of Minnesota Hospitals, degrees of descent were obtained in not more than 20 per cent of the cases. One reason for the successful results in some series is undoubtedly the inclusion of cases of pseudocryptorchidism.

To give a final estimate of the value of gonadotropic substance in the treatment of ectopic testes is impossible at this time. For one thing, the incidence of spontaneous descent is not accurately known. Furthermore, it must be determined whether endocrine therapy causes descent only of those testes which would descend without therapy about the time of puberty. Hormonal therapy makes it possible to differentiate between those testes which require surgical intervention because of mechanical obstruction to descent and those that do not.

Treatment of the retained testes should be deferred until 9 to 11 years since the testis does not grow grossly or microscopically until

thuja, tannic acid, or sodium psylliate. More necrosis was noted from the phenol preparation. It was not noted that more fibrous tissue was developed by one solution than by another.

With each solution the reaction at the end of twenty-four hours (Fig. 1) showed extensive edema, death, and beginning disintegration of fat and muscle fibers; there were occasional small areas of necrosis and a moderate leucocytic infiltration. At the end of one week (Figs. 2 and 3) the necrotic fat and muscle tissue were being removed, the edema was less marked, and there were fewer leucocytes. Sheets of young fibrous tissue containing newly-formed blood vessels enclosed the disintegrating muscle fibers.

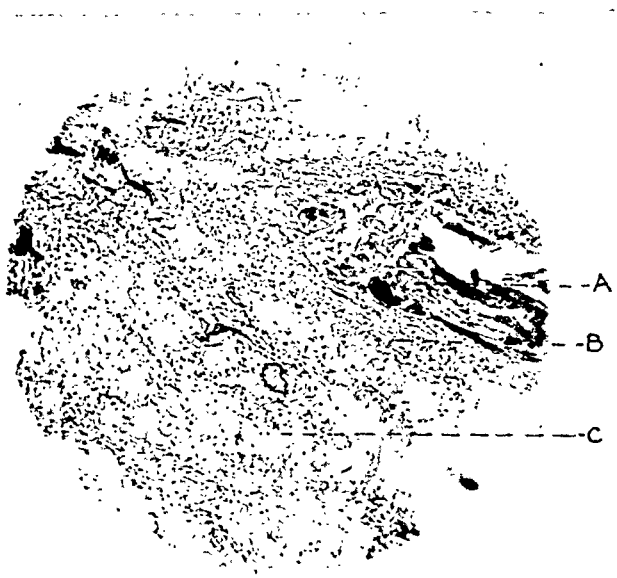


Fig. 1.—Dog I, twenty-four hours. *A*, Remaining muscle fibers, some of which show cloudy swelling and have lost their cross striations; *B*, necrotic muscle bundles; *C*, showing edema and a sparse infiltration of lymphocytes and plasma cells.

At the end of eight weeks dense bands of fibrous tissue extended between the remaining muscle fibers and muscle bundles.

In brief, our experimental studies and those of others[1-12] proved that the injection of certain chemicals does produce scar tissue.

Late Tissue Reactions.—Most of the published experimental studies do not show the tissue reactions beyond two to three months. Our sections of biopsies removed after ten months (Figs. 4 and 5) showed that the sheets of fibrous tissue had become markedly contracted as it became more adult in type. The fibrous bands contracted from each other and from adjoining muscle bundles and fat. In place of the diffuse sheets of fibrous tissue interlacing between the muscle bundles, as was noted during the first four months, the fibrous tissue generally appeared as small irregular scattered islands of compact, adult fibrous

THE LATE RESULTS OF THE INJECTION TREATMENT OF HERNIA

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THE treatment of hernia by the injection of sclerosing agents has passed the experimental stage into the stage of known results. Certain questions, however, have remained unanswered or only partially explained. These questions are: What is the fate of the fibrous tissue after a period of a year or more? What happens to the hernia sac? Can scar tissue alone cure a hernia? What types of hernias are suitable for the injection treatment?

During the past four years in the Hernia Clinic of the Department of Surgery of the Stanford Medical School, we have attempted to answer these questions. Experiments in the laboratory, the injection treatment of patients in the clinic, and careful follow-up studies have convinced us of the limited value of this method in the cure of hernia.

EXPERIMENTAL STUDIES

In June, 1935, experimental studies were begun in the Surgical Research Laboratory of the Stanford Medical School to determine the reaction of tissues to various solutions recommended for the injection treatment of hernia. The reaction of the tissues to solutions in common use were compared and the early and late effects were studied. We were particularly interested in determining what effect the injections would have upon the hernia sac and upon the cord and testicle, and particularly in how much fibrous tissue remained after six months or one year after the injections. Injections were made into the rectus muscle of dogs in one series and sections were taken at various intervals. In another series injections were made into the abdominal wall about the spermatic funiculus and the cords and testes were later removed for study.

Early Tissue Reactions (Twelve Hours to Four Months).—Our experimental studies included sections of tissue removed from the rectus muscle of dogs at intervals of twelve hours, twenty-four hours, forty-eight hours, one week, two weeks, four weeks, eight weeks, sixteen weeks, and ten months after the injection of various solutions in common use (Solutions 1, 2, and 3).* The reaction of the tissues to the various solutions was essentially the same for solutions of phenol and

Received for publication, December 20, 1939.

*Solutions: (1) phenol-thuja (25 per cent phenol, 25 per cent specific tincture of thuja, 50 per cent alcohol); dose, 6 minims; (2) proliferol (Ulmer); dose, 3 c.c.; (3) sodium psylliate, 5 per cent (Searles); dose, 3 c.c.

Reactions Within and About the Spermatic Funiculus.—Sclerosing solutions were injected into and about the spermatic cord in the inguinal canals of dogs, injecting one side and saving the other cord for comparison (Figs. 7 and 8). The injections were made at weekly

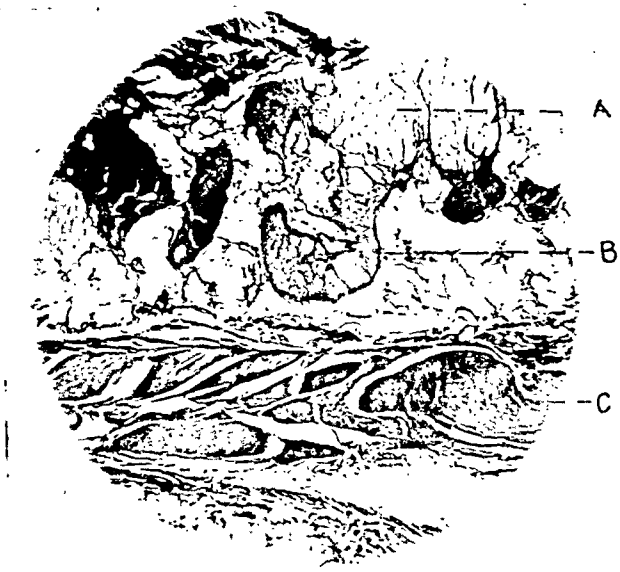


Fig. 4.—Dog III, section across the rectus muscle and posterior rectus sheath ten months after twenty injections given at weekly intervals. *A*, Remaining muscle bundles; *B*, scattered islands of compact fibrous tissue; *C*, rectus sheath.

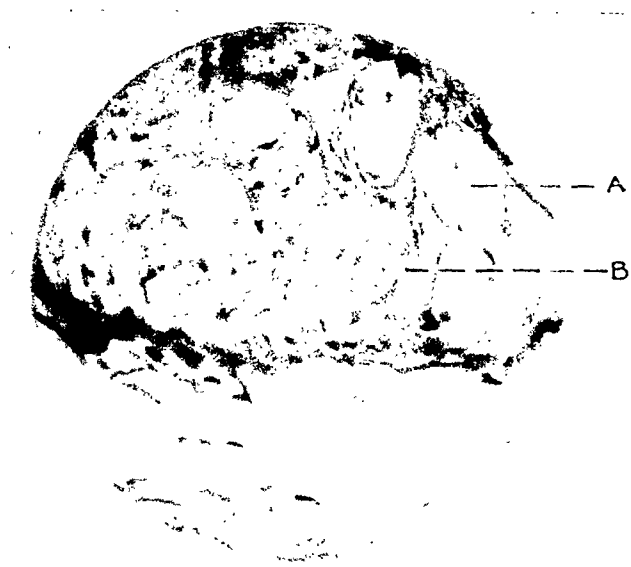


Fig. 5.—Dog III, high power of same section as shown in Fig. 4, showing remaining muscle cells with interlacing compact adult fibrous tissue (ten-months section). *A*, Muscle cell; *B*, fibrous tissue.

tissue. In a few areas the fibrous tissue extended through the entire thickness of the rectus muscle fusing the anterior to the posterior rectus sheath with septa of dense fibrous tissue (Fig. 6).

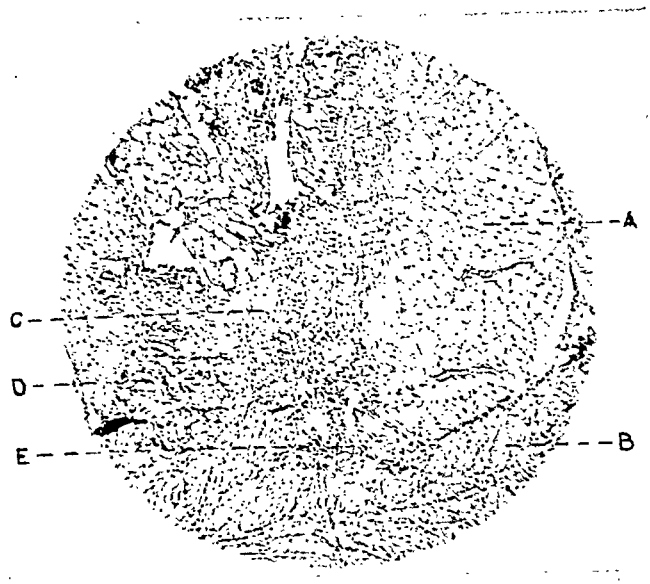


Fig. 2.—Dog II, one week. *A*, Muscle bundles of rectus muscle cut transversely; *B*, rectus sheath; *C*, sheets of young fibroblasts interlacing the remaining muscle bundles; *D*, partially destroyed muscle cells; *E*, small area of necrosis.

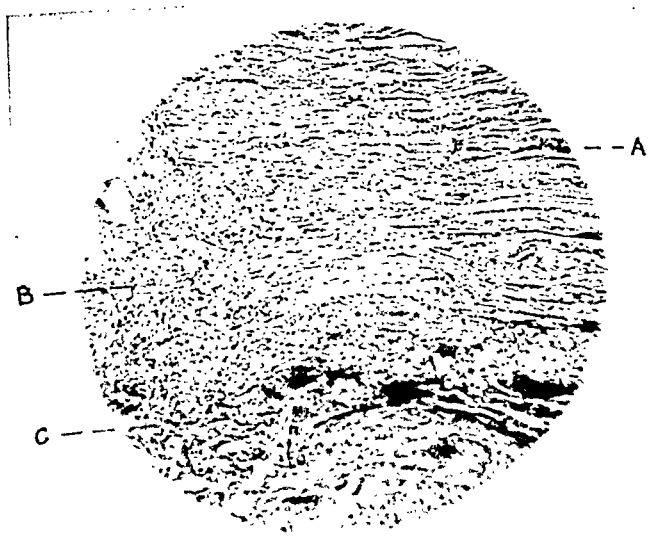


Fig. 3.—Dog I, one week. *A*, Rectus muscle fibers cut longitudinally, some of the fibers have been completely destroyed, others show clear swelling and loss of their cross-striations. *B*, young fibroblasts extending between the remaining muscle fibers. *C*, area of necrosis.

ticle. For experimental purposes this processus vaginalis may be considered a very thin hernia sac (Fig. 7).

In three out of four instances, when the injected cords were removed, it was still possible to pass a probe from within the abdomen to the testicle, indicating that the hernia sac had not been obliterated. In one case the injected area could not be passed with the probe.

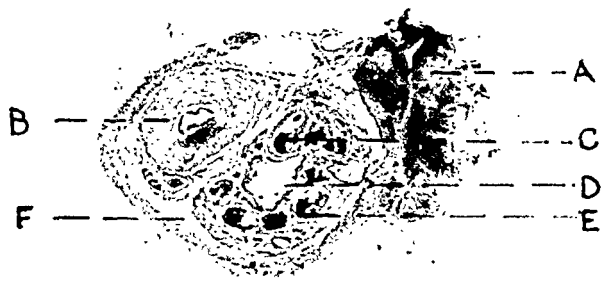


Fig. 7.—Dog VI B, section of normal spermatic funiculus. *A*, cremaster muscle; *B*, vas deferens; *C*, testicular artery; *D*, testicular vein; *E*, veins of the pampiniform plexus; *F*, processus vaginalis (hernial sac).

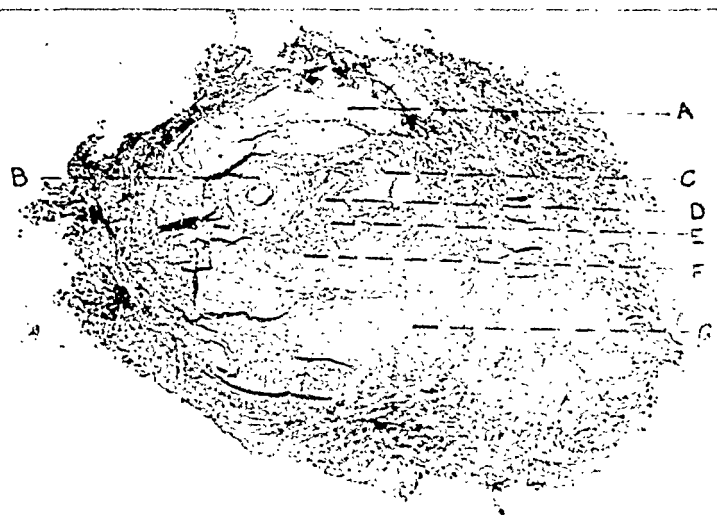


Fig. 8.—Dog VI A, injected spermatic cord one month after the tenth injection. *A*, Cremaster muscle; *B*, vas deferens; *C*, thrombosed testicular vein; *D*, compressed testicular artery; *E*, partially thrombosed veins of the pampiniform plexus; *F*, compressed but not obliterated processus vaginalis; *G*, mass of young fibrous tissue about the cord, fusing it to adjacent structures.

When the injected cords were removed and sectioned, it was noted that, even in the injected area, the contents of the fascial tube slipped out easily. It was difficult to cut off sections of the cord because the

intervals and in the same doses as are used in human subjects. One month after the tenth injection the cords and testes were removed and gross and microscopic studies were made to compare the injected and normal sides.

On several occasions following injections into the cord, a moderate thickening of the cord was noted extending down to the testicle. In these instances the testicle became swollen for two to three days. In one instance a nodular strand persisted along the entire length of the cord for forty-five days to the time the cord was removed. In none of the cases did the testicle become softened or atrophic.

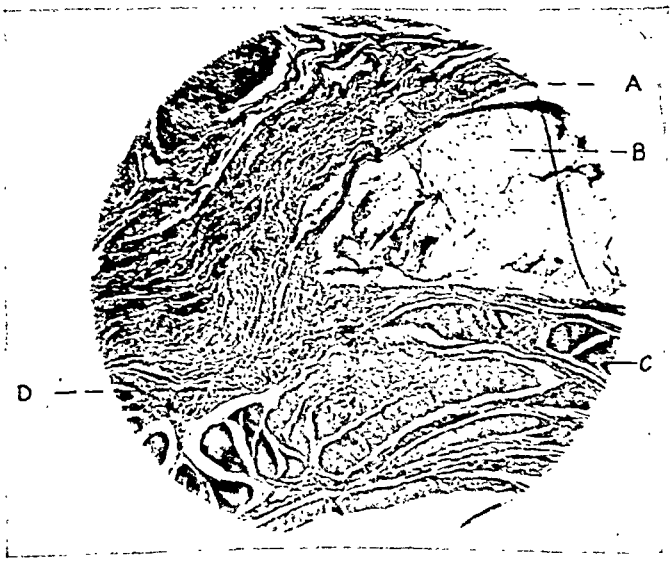


Fig. 6.—Dog III, ten months after twenty injections, showing how the band of dense fibrous tissue which extends from the anterior to the posterior sheaths is anchored to the posterior rectus sheath. *A*, Compact, mature fibrous tissue; *B*, remaining muscle fibers; *C*, posterior rectus sheath; *D*, anchorage of the fibrous septum.

Sections taken at 0.5 cm. intervals through the cord (Fig. 8) in the injected area showed a large mass of fibroblastic tissue about the cord, fusing it to the surrounding structures. Many of the veins within the pampiniform plexus were thrombosed and the testicular and deferens arteries were compressed.

Effect Upon the Ductus Deferens.—Sections taken at frequent intervals through the injected cords showed the ductus deferens to be preserved throughout. The lumen was patent and the epithelial lining was intact throughout. (Fig. 8.)

Effect Upon the Testicle.—Gross and microscopic examination of the testes from the injected cords showed no differences from the testes from the uninjected cords.

Fate of the Hernia Sac.—Dogs have a patent processus vaginalis. It is possible to pass a probe from within the abdomen down to the tes-

formly and entirely circumscribed by the fibrous tissue, it would contract and for a time narrow the defect. As the fibrous tissue sheets contract, the layer over the sac would be thinned out and the constant internal pressure within the sac would gradually expand it.

In the case of both the indirect and direct types of hernias the hydrostatic pressure within the sac would gradually stretch out the neck of the sac and permit the intra-abdominal contents to enter the sac. This would occur sooner with the direct hernias and later in most of the indirect types. In an occasional case of indirect inguinal hernia the sac would be obliterated in part by agglutination of the surfaces in contact.

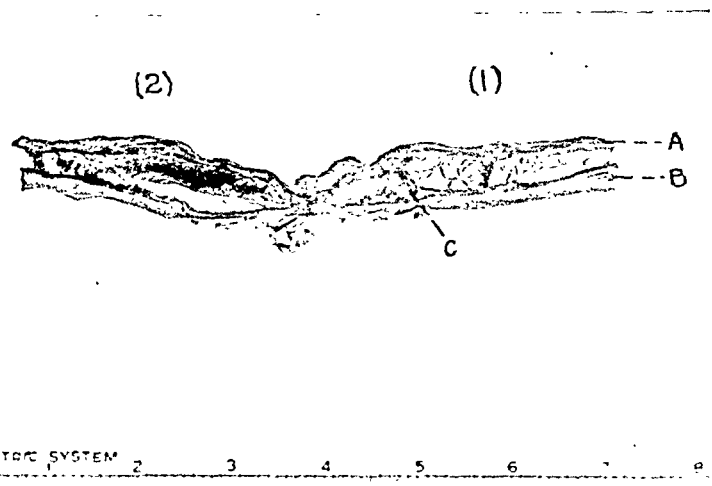


Fig. 9.—Dog III, section across rectus muscles and anterior and posterior sheaths; muscle (*1*) injected with twenty injections at weekly intervals. Specimen taken ten months after the last injection. *1*, Injected rectus muscle; *2*, control, uninjected muscle; *A*, anterior rectus sheath; *B*, posterior rectus sheath; *C*, bands of dense fibrous tissue fusing the anterior to the posterior sheath. Note on the injected side how the sheaths are fused to the muscle and to each other, while on the uninjected side the rectus muscle lies loosely within the sheaths.

Reasoning from the experimental results, therefore, we would not expect to cure (permanently) any direct inguinal hernia. We would expect to close (temporarily) all of the indirect inguinal hernias and many of the hernias would remain closed for months or years, even though the sac was not obliterated. A permanent cure may be obtained only in the rare case in which the sac is obliterated.

CLINICAL EXPERIENCE

The injection method of treating hernias was first employed in the Hernia Clinic of the Stanford Medical School in September, 1935. All types of hernias were at first accepted for the treatment, direct and indirect, large and small. Operative repair was advised in every case as the method of choice and an effort was made to arrange for an operation.

contents would slip out. Microscopic examination of the processus vaginalis showed a few areas in which there was destruction of the endothelial surfaces or agglutination of the surfaces with fibrous tissue.

Summary of the Tissue Reactions.—Following the injection of sclerosing solutions, there was destruction of muscle bundles and the cellular response of a low-grade inflammation with the development of sheets of fibrous tissue interlacing between the remaining muscle bundles. Within two months the fibrous tissue was dense and more adult in type. As time went on, the fibrous tissue contracted markedly, leaving small islands of compact fibrous tissue except for a few bands which extended through the entire muscle belly.

Injections into the spermatic cord produced a partial thrombosis of the veins with compression of the arteries. No changes could be demonstrated in the testes or ductus deferens. Although the processus vaginalis (hernia sac) was compressed, it was not obliterated except in one instance.

Discussion of the Results Which Might Be Expected on the Basis of the Experimental Studies.—In reasoning from the experimental studies alone we would expect that the solutions would be safe, would not produce an abscess or slough, and would not give any constitutional reactions. After about six injections there would be a firm mass in the injected area which would reach a maximum about two weeks after the last injection and then over a period of two or three months gradually disappear. The hernia sac would usually not be obliterated, but the neck of the sac would be compressed. In some cases in indirect inguinal hernia the sac would be obliterated in areas by the agglutination of the endothelial surfaces in contact. Although the induration would disappear from the injected area, strands of dense fibrous tissue would remain, fusing the aponeurosis of the external oblique to the cord and to the internal oblique muscles (Fig. 9). In an indirect inguinal hernia this would prevent dilatation of the neck of the sac and prevent omentum or bowel from dropping into the sac. In time the fibrous tissue would contract, become more compact, and pull away from the muscle, fat, or spermatic cord unless the fibrous septa were well anchored (Fig. 6), in dense fibrous structures such as the aponeurosis of the external oblique, the conjoined tendon, or the reflex inguinal ligament.

The whole basis of cure of an indirect inguinal hernia by the injection method is that the few remaining bands of fibrous tissue fuse the aponeurosis of the external oblique to the cord and the internal oblique and compress the neck of the sac.

In direct inguinal hernias the sac has a broad neck and there are no layers to fuse together to hold the sac compressed. The mass of fibrous tissue present for several months would act as an internal truss pad and hold the contents reduced, and, if the neck of the sac is uni-

TABLE I

TYPES OF CASES AND END RESULTS OF INJECTION TREATMENT OF HERNIA

TYPES OF CASES	CASES TREATED	RECURRENCE	NO FOLLOW-UP OF LESS THAN SIX MONTHS	PER CENT RECURRENCE
Indirect inguinal	68	20 (20/53)	15	37.73
Direct inguinal (includes saddle-bag type sacs)	21	13 (13/19)	2	68.42
Postoperative recurrent				
Direct defect	8	6 (6:6)	2	100.00
Indirect defect	2		2	
Femoral	1	1		100.00
Umbilical	1	1		100.00
Total	101			

currences were noted in 37.73 per cent of indirect inguinal hernias, 68.42 per cent of direct inguinal hernias, and 100 per cent of postoperative inguinal hernias. All of the postoperative recurrent inguinal hernias followed had direct defects.

COMPLICATIONS

Table II gives the list of complications noted in 1,909 injections given during the treatment of 101 hernias. It is to be noted that there were no serious complications.

TABLE II

COMPLICATIONS

(1,909 INJECTIONS IN 101 HERNIAS)

Transient swelling of abdominal wall	18
Transient swelling of spermatic cord	9
Transient swelling of scrotum	2
Pressure areas beneath truss	6
Intraperitoneal injection	2
Incarceration of hernia during treatment	2
Deaths	0
General reactions	0
Infections	0
Atrophy of testicle	0
Impotence	0
Sloughs	0
Peritonitis	0

DISCUSSION

Six months after beginning the injection treatment for hernias the results were very promising. It seemed that we were curing all of the hernias, direct and indirect, large and small. In the indirect inguinal hernias after four or five injections the tissues behind and above the external ring were firm and the external ring seemed tighter. The patients usually commented at that time that they were no longer

Between September, 1935, and June, 1938, 101 hernias in seventy-four patients were treated by the injection method. After one and one-half years it was found that the recurrence rate was so high for direct and postoperative recurrent hernias that thereafter only indirect inguinal hernias were accepted.

The patient was fitted with a semirigid frame truss (Smithsonian type) with a low posterior fulcrum. The truss was worn and adjusted frequently for one or two weeks before starting treatment. With the patient in the Trendelenburg position, the injections were started at the internal ring in indirect hernias and about Hesselbach's triangle in direct hernias. Subsequent injections were made down the canal as follows: internal ring, middle canal, above external ring, Hesselbach's triangle, internal ring, etc. Later injections were concentrated on the inguinal canal. The inguinal canal was also injected in cases of direct hernias and those with saddle-bag type sacs. Approximately one-half of the cases were treated with 5 per cent sodium psylliate (Searles) and one-half with proliferol T (Ulmer). The immediate and late results of the two solutions seem to be about the same. Three cubic centimeters of the solution was administered usually once a week. At first the injections were given two or even three times a week, but too much soreness resulted and the weekly interval was soon adopted. The patients never removed their trusses after the treatment was started. The patients with direct hernias received an average of twenty-five injections and the indirect received an average of eighteen injections. The postoperative recurrent hernias received an average of sixteen injections. The patients wore their trusses continuously for one month after the treatments were concluded and then were allowed to remove the trusses at night while in bed. On the average the successfully treated cases wore their trusses for ten months. Many of the patients were given two or even three courses of injections with a month or six weeks between the courses.

END RESULTS

Seventy-four patients, 70 males and 4 females, with 101 hernias were treated by the injection method between September, 1935, and June, 1938. There were 68 indirect inguinal hernias, 21 direct inguinal hernias (including hernias with saddle-bag type sacs), 10 postoperative inguinal hernias, 1 postoperative femoral and 1 umbilical. For estimating the end results only patients who had had their trusses off for more than six months after the last injection were considered. Some of the patients could not be located. Follow-up studies for from six months to two and one-half years were obtained on 53 indirect inguinal hernias, 19 direct inguinal, 6 postoperative recurrent inguinal, 1 postoperative femoral and 1 umbilical hernia. Table I gives the frequency of recurrences in the various types of hernias treated. Re-

showed a recurrence rate of 37.73 per cent in indirect inguinal hernias, 68.42 per cent in direct inguinal hernias, and 100 per cent in postoperative recurrent hernias.

7. We have concluded that the injection treatment of hernia should be used only in small indirect inguinal hernias in patients with otherwise good abdominal structures who will not or cannot be operated upon.

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1. Wolfe, R.: The Injection Treatment of Inguinal Hernia, M. J. & Rec. 133: 243-246, 1931.
2. Bratrud, A. F.: The Ambulant Treatment of Hernia, Minnesota Med. 18: 441-451, 1935.
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aware of a hernia; they no longer felt the impact of the sac against the truss pad when they coughed or strained. After twelve to fifteen injections the entire region about the inguinal canal was firm and the abdominal wall in that area was almost as firm as sole leather. The outline of the external ring could be palpated, but the finger could not be introduced into the canal. On introducing the needle for the injections, it was passed with difficulty through the layer of fibrous tissue which was 1 cm. or more in thickness. Usually the patient was then given a rest period of one month or six weeks during which time he wore the truss day and night. At the end of the rest period it was noted that the external ring had loosened up and much of the firm mass in and about the inguinal canal had disappeared. The patient was then given six to eight more injections. Following these injections, the external ring again became tight and the firm mass was again present in the inguinal canal. The patient continued to wear his truss day and night for another month and was then allowed to leave it off while in bed and while bathing. If any definite weakness was noted at that stage, many of the patients were given a third course of injections in the hopes of finally closing a small defect. The patient by that time had been wearing his truss eight to twelve months, had made thirty to forty office visits, and had received twenty to thirty injections. Most of the direct inguinal hernias recurred within three to four months after the last injection. All of the cases showed signs of disappearance of the scar tissue within two to three months following the last injection.

CONCLUSIONS

1. There are several solutions available which safely and painlessly produce fibrous tissue.

2. The sheets of fibrous tissue produced by the sclerosing solutions after four to six months contract to form scattered islands of compact fibrous tissue.

3. The hernia sac is rarely obliterated or even occluded at the neck by the injections.

4. Since muscle fibers are destroyed by the solution, large numbers of injections (over thirty) may weaken the abdominal wall in the injected area by replacing muscle with fibrous tissue which eventually stretches.

5. Since the sac is rarely obliterated, the whole basis of cure in the injection treatment of hernia is the fibrous tissue which persists between the fascial planes, muscle layers, and spermatic cord. These adhesions hold the hernia sac compressed and prevent omentum or bowel from entering the neck of the sac.

6. Follow-up studies on 101 hernias in 74 patients, followed for from six months to two and one-half years after the removal of the truss,

showed a recurrence rate of 37.73 per cent in indirect inguinal hernias, 68.42 per cent in direct inguinal hernias, and 100 per cent in postoperative recurrent hernias.

7. We have concluded that the injection treatment of hernia should be used only in small indirect inguinal hernias in patients with otherwise good abdominal structures who will not or cannot be operated upon.

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TRAUMATIC HEMOTHORAX

An Analysis of 276 Cases

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DURING the World War the frequency and high mortality of chest wounds directed a great deal of attention to them, and the knowledge of these injuries was correspondingly increased. At that time it was found that 25 per cent of such wounds resulted in empyema[1] when hemothorax developed and that a relatively large proportion required immediate surgery.[2-7] Civil injuries, numerous reports of which have appeared in the literature since then, differ strikingly from military injuries. Infection is rare, operative intervention is seldom necessary, and conservatism has become the keynote of treatment.

Hemothorax has been studied along general lines in the reports of chest injuries which have been published since the War, the excellent work of Boland[8] being typical. A detailed study of this common and serious complication, however, may result, in our opinion, in a more rational basis for treatment.

When a patient is seen with a chest wound in which hemothorax has developed, a number of questions immediately suggest themselves: Is this a case for masterly neglect? Should thoracentesis be performed? If so, when should it be done and how much blood should be aspirated? Is immediate thoracotomy required? What are the comparative results of extreme conservatism, aspiration, and operation? In an attempt to answer these and other questions, this analysis was begun.

MATERIAL

Two thousand ninety-one patients with penetrating and nonpenetrating chest wounds were admitted to Charity Hospital of Louisiana at New Orleans during the five-year period ending in 1936. Ninety-one were admitted more than once, which leaves 2,000 individual patients admitted during that period. Of these, 276 (13.8 per cent) were considered to have definite evidence of hemothorax. Only patients whose records showed one or more of the following findings are included in this study: (1) blood obtained by thoracentesis; (2) definite radiologic evidence of fluid in the pleural cavity; (3) definite physical findings of fluid, with a clinical course compatible with blood in the

Received for publication, November 24, 1939.

pleural cavity; (4) hemothorax found at autopsy. In addition, all cases were included in which death, presumably from hemorrhage, occurred within twenty-four hours after admission. Such rigid criteria undoubtedly excluded many patients who had minimal collections of blood, for the incidence of hemothorax at Charity Hospital was only 13.8 per cent, against an incidence of 63 per cent reported by Boland in 1,187 chest injuries.[8]

Gunshot wounds slightly outnumbered the stab wounds, and there were 2 crushing injuries. Various types of knives or pistols were the usual weapons, but shotguns accounted for 10 injuries and ice-picks for 11. Two hundred eighteen of the 276 patients were negroes, and males predominated in the proportion of 4:1. Only 28 patients were admitted later than twenty-four hours after injury, and most were admitted within the first hour. A few patients were probably dead when the ambulance arrived and are necessarily excluded from these statistics. Treatment was supervised by twenty-six different surgeons and represents a cross section of the therapeutic practice of this community.

MORBID ANATOMY

Since most of the autopsies performed in this series were done in the coroner's office, post-mortem findings could not be studied in detail. Some studies, however, appear in the literature. Bradford[9] observed that in such cases the diaphragm on the affected side is elevated and the lung somewhat collapsed, especially in the lower lobe. Emphysema is present in the upper lobe. Like Morelli[10] and Bastianelli,[11] he found that the collapsed portion of the lung rarely, if ever, shows signs of inflammation except in the immediate vicinity of the wound tract. Purulent bronchitis is sometimes present in portions of the lung which are not collapsed.

Deposits of fibrin are present over the pleural surfaces, especially in the costovertebral groove and costophrenic angle. This fibrin, which is present in greater amounts in infected cases, forms the framework for connective tissue formation. There is more pleural exudate present in infected cases, as well as more polymorphonuclear leucocytes. Massive clotting of the hemothorax is also more common in infected cases.

The fact that blood in the pleural cavity and blood removed from it frequently fail to clot has been explained in several ways. Bradford and Elliott,[1] quoting Elliott and Henry, state that some clotting occurs in all cases, after which a separation of serum from the clot produces a brownish red fluid which on standing forms a gelatinous mass, or that the churning movements of respiration whip out the fibrin into layers on the pleural surfaces, leaving the blood defibrinated. Brown and Debenham[12] believe that blood is defibrinated in most cases and that contaminated blood always coagulates. Sandi-

son and Elkin[13] demonstrated experimentally that clotting is more likely to occur when air is added to the hemothorax. Van Allen,[14] discussing their contribution, says that the pleura in human beings has an anticoagulant property and that clotting occurs only when hemorrhage is so rapid that all the blood cannot come into contact with the pleural surfaces.

SYMPTOMATOLOGY

Roughly, one-half of the patients had varying degrees of dyspnea and chest pain. In one-third of the cases the chief complaint was bleeding from the wound. Hemoptysis was recorded in 28.9 per cent of the cases and faintness in 22.5 per cent. Thirteen patients complained of abdominal pain, but intra-abdominal injuries were not invariably associated with this symptom.

PHYSICAL FINDINGS

Most of the patients seemed apprehensive, and the pulse and respiration were rapid in the majority of cases. Varying degrees of shock were noted on admission in 117 cases. The wounds, which involved every conceivable portion of the chest, were often multiple and were sometimes associated with injuries to other parts of the body and the extremities. One patient with a large hemothorax had a single wound at the base of the neck involving the subclavian artery. Many gunshot wounds were through and through, and several wounds were of the sucking variety.

Normal chest signs were elicited upon admission in 35 cases, in 8 of which abnormal signs developed one to twelve days later. On the affected side the usual findings were lagging, decreased vocal fremitus and resonance, dullness ranging to flatness, and decreased or absent breath sounds over the area of fluid, with skodaic phenomena above. Various types of râles were sometimes noted, usually in the area of the wound. In 33 cases the heart was displaced to the uninjured side, and surgical emphysema was demonstrable in 55.

Hemopneumothorax was suspected more often than it was actually present, due to the skodaic phenomena above the fluid in simple hemothorax. Tympany above the dullness furnished the clue to the correct diagnosis. Succussion splash was rarely noted and the coin test was rarely positive.

The diagnosis of hemothorax was frequently missed on the first examination, the condition being considered simple pneumothorax or pneumonitis. Adhesive strapping usually interfered with chest examination.

There were two undoubted cases of massive pulmonary collapse in this series, one of which was diagnosed before radiologic study. The complication should be easy to recognize if it is borne in mind. The

chief differential point is the displacement of the mediastinal structures toward the affected side. Bradford[15] and Curl,[16] who discuss the condition as a complication of chest wounds, believe that phrenic nerve paralysis is a causative factor. Coryllos and Birnbaum,[17] discussing massive pulmonary collapse in general, offer convincing evidence that obstruction of a bronchus is the usual etiologic factor, and support their deductions with experimental proof. There is no reason to believe that massive collapse which accompanies chest injuries differs materially from the collapse which occurs in other conditions. Curl[16] has called attention to the occurrence of contralateral pulmonary collapse in chest injuries, but there were no examples in this series.

Boland[8] considers that elevation of the diaphragm in penetrating chest wounds may be due to phrenic nerve paralysis or to atelectasis. The occasional occurrence of massive collapse in hemothorax and the frequent elevation of the diaphragm suggest the probability that the latter condition is the result of the presence of small areas of atelectasis which are not sufficiently large to displace the mediastinum.

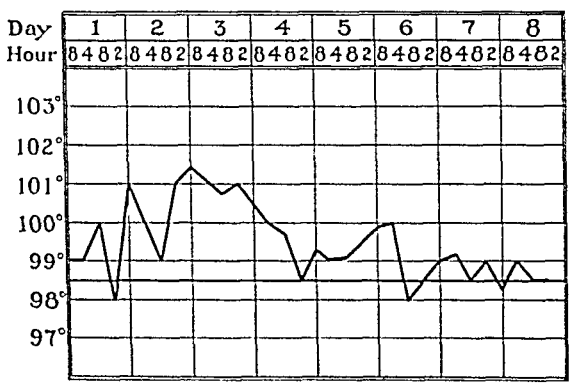


Fig. 1.—Typical temperature chart in sterile hemothorax.

The temperature curve is so characteristic in hemothorax that the presence of the complication can often be surmised from this portion of the chart alone. After recovery from the subnormal level of shock has ensued, the temperature rises rapidly to 101 to 103° F., the elevation continuing with daily small oscillations for from three to five days. Then, usually within the next three or four days, it falls by lysis. Patients with large or infected hemothoraces often have higher temperatures for longer periods of time.

In a few cases in this series the temperature remained normal, even though there were large accumulations of blood. In many minimal cases it rose only to 99 to 100° F., and only for a day or two. Temperatures of 103 to 105° F. with marked oscillations during the second week usually indicated that the hemothorax was infected. In

the average sterile case, however, the curve was typical, and, even when the initial physical findings were negative, future examinations usually revealed the presence of blood (Fig. 1).

RADIOLOGIC STUDIES

Radiologic studies were made in 95 cases, in which 299 films were taken. This method is a valuable adjunct to diagnosis, although it is subject to misinterpretation. Small collections of fluid were accompanied by an elevation of the diaphragm and obliteration of

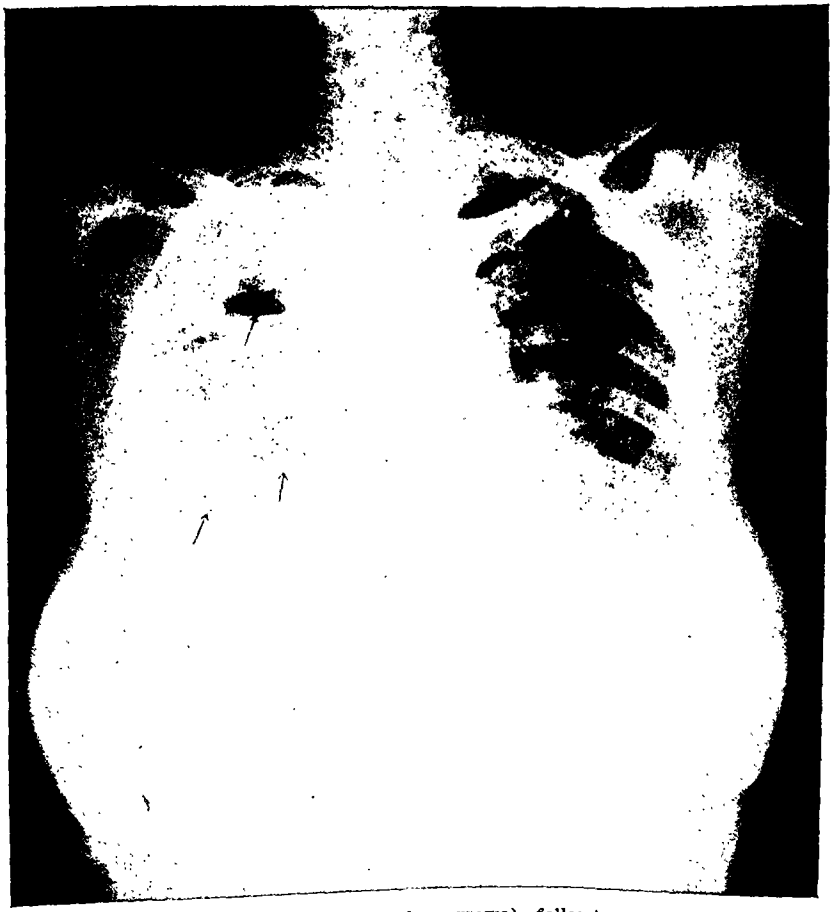


Fig. 2.—Multiple fluid levels (indicated by arrows) following aspiration and air replacement.

the costophrenic angle on the affected side. Larger collections produced varying heights and degrees of opacity, usually with displacement of the heart and mediastinal shadow to the uninjured side except in cases of massive collapse. One or more fluid levels were noted if air was present in addition to blood. Seven cases, after aspiration

and air replacement, presented a picture of multiple fluid levels (Fig. 2). This appearance, it is thought, was due to the presence of fluid held on numerous shelves of adhesions between the pleural surfaces rather than to encapsulations of fluid.

Normal radiologic findings immediately after injury were later replaced by pathologic findings in four cases. The number of such cases would undoubtedly be increased had more re-examinations been made. Head[18] has reported several cases in which hemothorax apparently developed from one to six weeks after the thoracic injury. Repeated radiologic examinations are necessary, for, in some cases, instead of the usual absorption of blood, progressive hemorrhage occurs.

Pneumonitis, which can frequently be diagnosed by radiologic findings, was present in 12 cases. A rather frequent error, made by depending on radiologic findings alone, was to mistake for pneumonitis at the base of the lung small collections of blood which did not displace the heart. In 12 such cases physical findings pointed definitely to the presence of fluid, and in 2 others blood was actually aspirated. The same error is likely to occur when radiologic findings are compatible with the presence of a thickened pleura.

It was also possible to demonstrate by radiologic study such conditions as pulmonary collapse, adhesions, encysted fluid, foreign bodies, fractures of ribs and other thoracic bones, and surgical emphysema.

CLASSIFICATION

Small hemothoraces include those cases in which the blood present ranges from a minimal amount to a collection extending to the posterior arc of the ninth rib. Moderate hemothoraces include those cases in which the fluid extends from the ninth to the sixth rib. Any collection which extends beyond this point is classified as large. In this series there were 103 small, 50 moderate, and 123 large hemothoraces, 33 of the latter group showing a total opacity of one side of the chest to the x-ray. It must be remembered that a single case may fall into each of the classifications at various stages of its progress. Hemothoraces are also classified as sterile and infected.

INFECTED HEMOTHORAX

Diagnostic aspiration, with smear and culture, is the most dependable means of determining infection of the blood in the pleural cavity, but certain clinical points are of distinct aid. In general, infection should be suspected in any case in which the progress is not favorable and in which increasing hemorrhage has not occurred. Bradford and Elliott[1] suspect infection and institute bacteriologic studies in any case in which: (1) fever is atypical; that is, is more irregular than is usual or is sustained at a steady high level; (2) the pulse rate is 100 to 120 or higher; (3) dyspnea is increasing and is

out of proportion to the physical signs; (4) the tongue is furred, as is usual in cases due to streptococcal infection; (5) sleeplessness or mild delirium is present; (6) pain and tenderness develop in the affected side; (7) a contralateral dry pleurisy develops.

Twenty-eight of the 276 patients in this series, 10.2 per cent, had bacteriologic or clinical evidence, or both, of infection of the hemothorax. This represents an incidence of 7.5 per cent of the gunshot wounds, and 13.7 per cent of the stab wounds. If all the chest wounds (2,000) from which the 276 cases of hemothorax were selected are considered, the percentage of infection becomes 1.4 per cent, which approximates the incidence reported by Boland,[8] who noted 17 cases of empyema in 1,187 chest injuries.

Bradford[9] has called attention to the fact that fluid aspirated from one part of the chest may be sterile, while at the same time abundant organisms may be found in fluid from another portion. This observation must be borne in mind when infection is suspected and cultural studies are negative.

In the 28 infected cases in this series the infection was due to *Staphylococcus albus* in 4 and *Staphylococcus aureus* in 3. In the remaining cases one or more of the following organisms were present: gram-negative bacilli, gram-positive diplococci, short-chain streptococci, *Bacillus pyocyaneus*, anaerobic streptococci, fusiform bacilli, *Endamoeba communior*, *E. coli*, *Hemophilus influenzae*, and Friedländer's bacilli.

THERAPY

No immediate thoracotomies were performed. In most cases immediate therapy consisted of suture of the wound (sucking wounds being closed without drainage), control of external hemorrhage, and the usual measures to control shock, including liberal doses of morphine and other sedatives, and infusions and transfusions as indicated. Autotransfusion, as recommended by Brown and Debenham,[12] was not employed in any case. The chest was usually strapped. Tetanus and anaerobic antitoxin were injected, and x-ray examination of the chest was done if the patient's condition permitted. Patients in grave condition were kept in the observation room and not transferred to the general surgical ward until considerable improvement was evident. Further treatment consisted in adequate sedation and careful observation for the possible development of complications.

In all, 61 patients who had large hemothoraces and were not progressing favorably, or who were not progressing favorably for other reasons, were subjected to thoracentesis. Ten of the aspirations were done for purely diagnostic purposes, the remainder being therapeutic.

If aspiration was done, it was usually begun after the third day and the blood was only partially removed. In one-half of the cases

in which this method was employed, it was begun after the first week, and in a few cases in which symptoms were urgent, it was begun before the third day. The average amount of blood removed at one tap was 300 c.c., with the upper and lower limits varying from a few to 1,350 c.c. The procedure was repeated as necessary, and 10 patients were tapped from three to eleven times. The majority, however, required but one aspiration. In 17 cases, in 5 of which complete aspiration of the blood was apparently done, an amount of air equal to the amount of blood removed was injected into the pleural cavity.

Aspiration was usually followed by symptomatic relief and an improvement in the general condition which was more likely to be sustained in the sterile than in the infected cases. In 16 cases the temperature dropped immediately, but, unless aspiration was complete, usually rose again in twenty-four to forty-eight hours. The few patients who were treated by early complete aspiration and air replacement seem to have progressed well with but one exception. In this case there was a rapid reaccumulation of blood immediately after each aspiration, and it seems highly probable that an intercostal artery continued to bleed. The patient finally died.

In 2 instances taps were done to relieve a tension hemopneumothorax. Manometric studies were recorded in 1 of these cases.

When infection was diagnosed, immediate thoracotomy was performed in 4 cases. In 16 others aspiration, usually with air replacement, was continued. Two of these patients developed empyema necessitatis and 7 others were subjected to thoracotomy later. In the 11 thoracotomies in the infected group (9 open and 2 closed) there was 1 death, which was proved at autopsy to be due to a heart wound. There were 2 deaths in the 9 infected cases treated by aspiration alone. One of these deaths was due to a spinal cord injury and the other to a *Streptococcus hemolyticus* infection.

Bradford and Elliott[1] treated 48 cases of septic hemothorax by repeated aspiration, with 20 deaths, and 69 cases by rib resection, with 16 deaths. The conclusion would seem to be inevitable that infected hemothorax should be treated by open thoracotomy. Even though the mortality statistics are not comparable, an analysis of the infected cases in our own series would seem to lead to the same conclusion.

MORTALITY AND MORBIDITY

Of the 276 patients with hemothorax, 70 died, 17 were discharged unimproved, and 189 seemed entirely well on their discharge from the hospital. The uncorrected mortality for the whole series is thus 25.4 per cent. Forty-six patients, a substantial majority, died within twenty-four hours after admission (Fig. 3), most of them being moribund when they were brought into the hospital. If this group be excluded, the mortality is 8.7 per cent. Since hemorrhage probably

played the most important part in the early deaths, it would seem that this group of immediately fatal cases offers a field for investigation and salvage (Fig. 4).

Forty of the deaths followed gunshot wounds, and 18 followed stab wounds. In the remaining 12 cases the injuries were by unknown weapons. Although 3 deaths occurred in the infected group, infection was the cause in only 1, the other two, as has already been mentioned, being due to other injuries (1 bleeding intercostal artery, 1 spinal section). Our figures thus support the conclusions of Boland[8] and others that infection plays only a small part in the mortality of chest wounds in civil practice. It contributed materially, no doubt, to the period of disability, but we cannot prove this, as we have no adequate follow-up on our cases. Elliott,[19] however, found that soldiers could be returned to the front on an average of two months after chest injuries, even when the wounds were complicated by empyema.

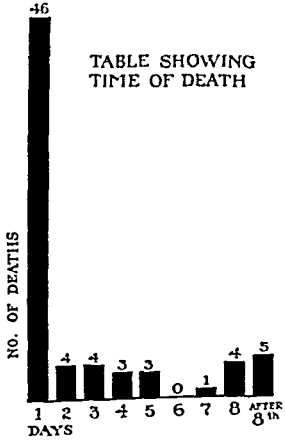


Fig. 3.

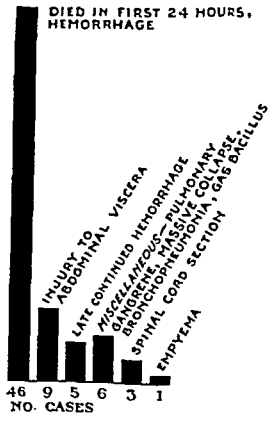


Fig. 4.

Fig. 4.—Cause of death in 276 cases of traumatic hemothorax.

Further analysis of the 24 deaths which occurred after twenty-four hours reveals 12 in which hemothorax was only a contributory cause of the fatal outcome. Three patients had complete spinal cord section and 9 had abdominal injuries, which in 3 cases were complicated by spinal cord severance. In the remaining 12 cases, death was due in 5 to continued hemorrhage, either externally or into the chest, and in 2 to bronchopneumonia. Pulmonary gangrene, massive collapse of the lung, gas bacillus infection, empyema, and cardiac injury accounted for 1 death each. Terminal bronchopneumonia was usually present in the fatal thoracoabdominal cases.

The mortality in the patients who survived the first twenty-four hours and who had only chest injuries was thus 4.3 per cent. In the

17 cases of hemothorax complicated by abdominal injury the mortality was 76.5 per cent. Heyd[20] noted a mortality of 60 to 75 per cent in such cases, and Heuer,[21] a mortality of 56 per cent. Complete section of the spinal cord was invariably fatal.

DISCUSSION

The analysis of these 276 cases supports Coryllos'[22] warning that therapeutic standardization is dangerous in chest injuries, and it seems well to bear in mind that, if civil injuries resemble war wounds, as they often do, routine conservatism is very dangerous. The indications for early surgical intervention, in an attempt to reduce the early mortality and prevent complications, have been discussed by Duval,[2] Heuer and his associates,[3] Anderson,[4] Roberts and Craig,[5] Gray,[6] and Hathaway,[7] among others, and need no elaboration here, for most of these authors derived their experience from war wounds.

The source of the blood in hemothorax is an important consideration, but it is not always easy to determine. The clinical course must furnish the answer unless immediate thoracotomy is obviously necessary. The more resistant is the hemorrhage to conservative measures, the greater is the likelihood that its source is an intercostal artery, the internal mammary artery, or a larger vessel. Repeated secondary hemorrhages from the wound are usually from a wounded intercostal or internal mammary artery. Even if the patient survives the first two or three days, death from hemorrhage will probably eventually occur under such circumstances, as it did in 5 cases in our series.

Morelli,[10] Bastianelli,[11] Foster,[23] and Allen,[24] among others, believe that, if the patient survives the first few hours, the most frequent source of the hemorrhage is likely to be a laceration of the lung, usually involving only the smaller vessels. The conservative treatment of civil cases is based on this presumption, plus the assumption that accumulating blood in the pleural cavity will act as a tamponade and control the hemorrhage. Aspiration, for this reason, is not advised by some writers until after the third day, by which time active bleeding will have ceased and firm clots will have formed in the severed vessels.

Morelli[10] and Bastianelli,[11] on the other hand, recommend immediate aspiration of blood with the replacement of enough air to maintain a positive intrapleural pressure, the procedure being carefully controlled by manometric observations. In their opinion air is a more effective tamponade than blood, 1,500 to 2,500 c.c. of which, according to Bastianelli, is necessary for effective tamponade; and even this amount does not produce complete collapse and immobility of the lung. Air under positive pressure, he contends, compresses the lung, coapts the edges of the pulmonary wound, checks hemorrhage of the average degree, diminishes infectious complications, and prevents

adhesions. In this country Brunn[25] and Foster and Prey,[26] among others, have reported good results with this method. Others who have not utilized it have apparently not done so because they are satisfied with their results by other methods.

The fear of initiating further hemorrhage has undoubtedly been responsible for the development of the attitude of masterly neglect in the management of hemothorax, at least in the early stages. Immediate thoracentesis, however, is mandatory in large collections of blood producing respiratory or circulatory embarrassment because of mediastinal displacement, and in cases of high pressure hemopneumothorax. Immediate closure is indicated in sucking wounds; thoracotomy, in large lacerations of the lung, bleeding intercostal or internal mammary arteries; and thoracotomy or laparotomy, in thoracoabdominal wounds. Injured intercostal mammary arteries are frequently the cause of recurring hemorrhage into the chest and are indications for thoracotomy. Air-tight closure of the wound after thoracotomy is the procedure of choice. The chances of later infection by this plan cannot be ignored, but the disturbances of physiology produced by the presence of drains in the pleural cavity at this stage are more serious, and infection, if it occurs, can be dealt with as necessary when the patient is not in extremis.

SUMMARY AND CONCLUSIONS

1. Two hundred seventy-six cases of hemothorax following chest injuries have been analyzed with reference to incidence, symptomatology, signs, diagnostic methods, and therapeutic procedures.

2. The symptoms, signs, and temperature curve usually make diagnosis simple. Properly interpreted x-ray films are a valuable aid. It is important to remember that signs of hemothorax may develop many days following the original injury.

3. Hemothorax is frequently associated with serious visceral injuries, which are the chief cause of the high mortality.

4. Infection of the hemothorax seldom occurs and is not a frequent cause of death in civil cases. Its occurrence is an indication for open drainage.

5. Immediate operative intervention in selected cases is suggested as a possible means of reducing the high mortality rate in the first twenty-four hours. Repeated or continued bleeding from the chest wound and rapid reaccumulation of the hemothorax indicate that an intercostal or internal mammary artery has been severed. Immediate operation is indicated in such cases. Five deaths, all classed as preventable, are reported from this cause in this series.

6. Other indications for immediate operation include open sucking wounds, large lacerations of the lung, and large or heavily contaminated foreign bodies in the thoracic cavity.

7. Conservative treatment usually yields satisfactory results in patients who survive for twenty-four hours. Routine conservatism, however, is unsafe and dangerous. Early complete aspiration and controlled positive pressure air replacement seem to be based on sound physiologic principles and deserve a more extensive trial in sterile cases. To speak generally, aspiration is indicated for diagnostic purposes, as well as in large hemothoraces and in cases in which pressure symptoms are present.

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subperiosteal portions of the shaft. Destruction of cortical bone in these areas was incomplete. Each extremity of the lesion was sharply demarcated by a circumscribed, partly cystic medullary nodule 2 cm. in diameter.

The microscopic structure of the tumor was not uniform. The typical and predominating picture was that of solid and partially cystic masses of dark-staining cells irregularly distributed through and sharply demarcated from a dense fibrous



Fig. 1.—Roentgenogram of right leg, showing extensive destruction of tibial shaft and a soft tissue mass.

Fig. 2.—Posterior half of tibia. The extensive replacement of the shaft by tumor tissue is well shown. The soft tissue mass had been removed prior to amputation.

stroma which in a few areas presented islands of osteoid tissue (Figs. 3 and 4). These cellular masses were of variable size and were irregularly circumscribed or elongated. For the most part their peripheries were sharply demarcated by a layer of regularly arranged cells which had large nuclei and small amounts of cytoplasm

ADAMANTINOMA OF THE TIBIA

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IN 1913 Fischer[6] reported a primary epithelial tumor of the tibia which he called an adamantinoma. Since that time but few tumors of the same type have been described. Because of this apparent rarity, the report of an additional case seems justifiable. The previously reported cases and the concepts of the histogenesis of tibial adamantinoma are reviewed.

CASE REPORT.—A white girl, 14 years of age, was admitted to the University of Minnesota Hospitals, July 13, 1938, complaining of pain and swelling in the right leg and difficulty in walking. Symptoms had been present since December, 1935, when pain was noted in the right tibia and a small mass appeared in the painful area. The mass persisted and in April, 1936, the lesion was curetted. Healing was temporarily complete and there were no further symptoms for a period of six months. Pain and a mass recurred and curettage was repeated in July, 1937. There was again relief from symptoms although the wound drained until February, 1938. Pain and difficulty in walking recurred by June, 1938, became much more severe, and for the week prior to admission to the hospital the patient had been on crutches.

The past history was not significant. The patient had had measles in 1929 and had undergone a tonsillectomy in 1936. There had been no injury of any kind to the affected leg. Significant physical findings were confined to the right leg. A resistant, slightly tender tumor mass about 4 cm. in diameter was palpable over the anterior tibial surface. In the skin overlying the mass was an old operative scar, the anterior end of which presented a small, nondraining sinus. Roentgenograms showed a destructive lesion extending for a distance of approximately 15 cm. along the shaft of the lower half of the tibia (Fig. 1). The bone was somewhat expanded, and presented a multicystic appearance and areas of cortical destruction. There was a soft tissue mass on the anteromedial aspect of the bone within which small bone spicules were visible. There was a small area of periosteal new bone formation on the lower posterior aspect of the tibia.

On July 18, 1938, the involved area was explored and the soft tissue mass was removed. On July 20, 1938, a low thigh amputation was performed. Convalescence was uneventful and the patient was discharged from the hospital on Aug. 18, 1938.

Pathologic Examination.—The specimen removed at the exploratory operation measured 6 by 5 by 3 cm. Centrally it presented a collapsed, smooth-walled cystic cavity. Otherwise the tissue was uniformly solid, grayish white in color, and irregularly traversed by fibrous trabeculae. Peripherally there was no distinct capsule; in part the tumor was limited entirely by adherent adipose tissue and in part by dense conective tissue.

The tumor involved a segment of the tibia 18 cm. in length between points 2 cm. above its lower, and 13.5 cm. below its upper extremities (Fig. 2). The midportion of this segment was almost completely replaced by solid, moderately firm, grayish white tissue. A thickened periosteal capsule covered a slightly lobulated surface posteriorly and laterally. Shell-like remnants of cortical bone persisted in some areas. A large defect on the anteromedial aspect of the mass corresponded to the plane of excision of the previously removed tissue. In this region tumor tissue was adherent to, and appeared to infiltrate, adjacent muscle and fascia. In its distal 4 cm. and proximal 6 cm. the tumor was confined chiefly to the medullary and

Received for publication, November 20, 1939.

For the group a common histologic structure obtains. Illustrations accompanying the several case reports are, to a large extent, interchangeable. In all instances an organoid pattern predominates. The additional feature of foci of cornification was noted in one case. The usually abundant stroma occasionally contains giant cells and in our case presented rare islands of osteoid tissue. That several cases, particularly in recurrences, presented loss of the typical organoid structure is worthy of comment. Diffuse cellular masses and interlacing

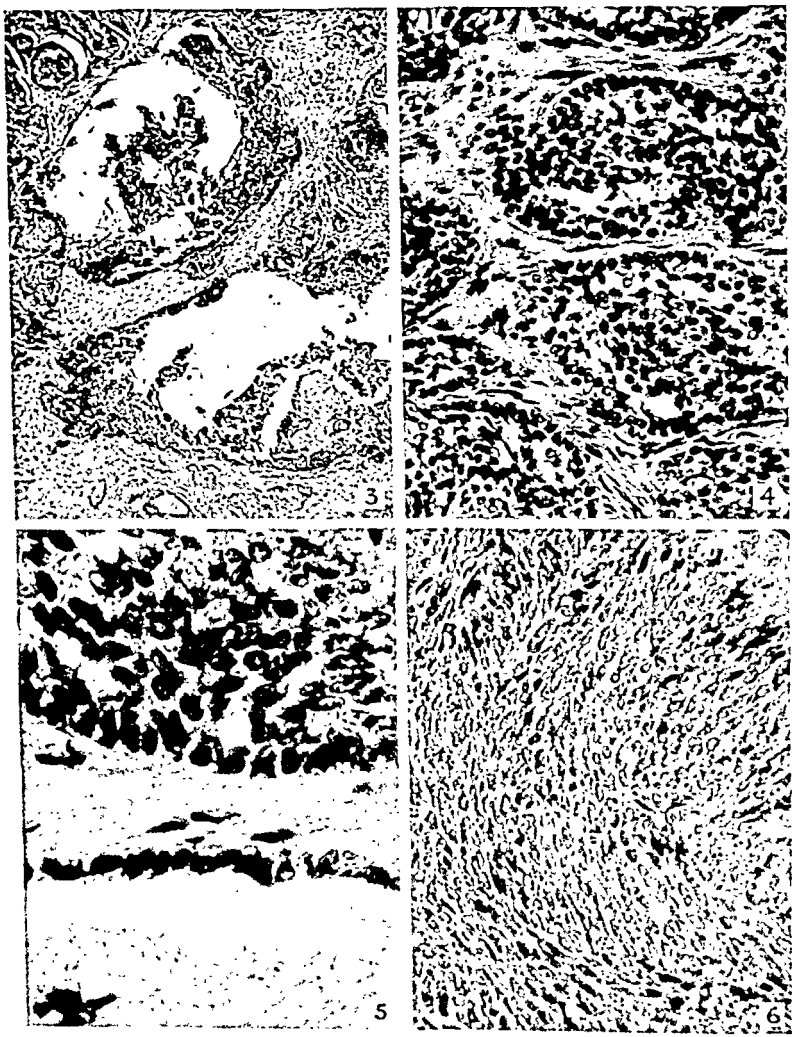


Fig. 3.—Section showing irregular distribution of islands of tumor tissue and emphasizing their frequent cystic character. (Hematoxylin-eosin, ×65.)

Fig. 4.—Section from the nodule which demarcates the proximal extent of the tumor (Fig. 2). Note the manner in which islands of tumor tissue are sharply demarcated from the stroma and the irregular cellular arrangement in their central portions. (Hematoxylin-eosin, ×250.)

Fig. 5.—Higher magnification of area similar to that shown in Fig. 4. (Hematoxylin-eosin, ×100.)

Fig. 6.—Section from peripheral portion of soft tissue mass, showing loss of typical structure and the assumption of a sarcoma-like appearance. (Hematoxylin-eosin, ×350.)

(Figs. 4 and 5). Centrally similar, but oval to spindle cells were closely packed or, when few in number, formed an irregular network of stellate, branching forms. In such areas the cytoplasm was drawn out into long processes. Spaces in the central portions of these masses varied from narrow clefts to large, well-defined cysts. Cysts lined only by a peripheral layer of cuboidal cells were fairly numerous. In other portions of the tumor diffuse masses of closely packed, frequently spindled cells lacking the palisaded border were distributed through a similarly fibrous stroma. In extreme peripheral portions of the tumor these cellular masses encroached upon skeletal muscle. In some of such areas interlacing bands of cells simulated the appearance of spindle-cell sarcoma (Fig. 6).

REVIEW OF LITERATURE

Fifteen cases of tibial adamantinoma are summarized in Table I. Individuals of both sexes and of variable ages have been affected. In this series there are 9 males and 6 females. The oldest patient was a woman 57 years of age; the youngest, a boy 12 years of age. The tumor has appeared in either tibia and in any portion of its shaft. As with many tumors, and with bone tumors in particular, there has frequently been a history of trauma. Common symptoms of pain, swelling, and difficulty in walking have been present for as short a period as six weeks and for as long as eight years before the institution of therapy. For the group the average duration of symptoms reasonably attributable to the tumor is roughly twenty-seven months. The therapeutic approach has varied. A preoperative diagnosis has been made in but 1 case and in that by aspiration biopsy. Primary amputation was performed in 1 case and followed unsuccessful radiation in another. Curettage has been followed by prompt recurrence in 6 cases. Of these patients, 5 were ultimately subjected to amputation and 1 was successfully resected. Resection and bone graft were successful in 3 cases. Local excision was followed by recurrence in 3 cases and was successful in 1. Of those that recurred, 1 was successfully re-excised, 1 successfully resected, and 1 came to amputation. In no case in which it has been employed has there been a favorable response to radiation. Metastases have not been reported. As a group the cases have been followed for too short periods of time to justify any generalities concerning the ultimate outcome. In Case 6, for example, there was no recurrence until two years after the primary excision.

The tumor involves the tibial shaft to a variable extent. In a few instances it has been confined to the subperiosteal-cortical portions of the bone, while in the majority the medullary cavity is also involved. In several instances the expanding tumor, which carries with it a capsule more or less continuous with the periosteum, has encroached on the adjacent soft parts. The shaft of the bone is eroded, destroyed, and but rarely expanded. The bone at the extremities of the tumor or remnants of incompletely destroyed cortical bone may present areas of increased density. In no case thus far reported has the epiphysis been invaded.

9	1938	Oberling et al.[11]	51	M	Middle third	?	?	?	Excision	Recurred; amputated 7 mo. later
10	1938	Dunne[4]	32	M	Junction upper middle thirds, left	Contusion, abrasion	9 mo. ±	Swelling, 4 yr.; pain later mo.	Deep x-ray	Progression; amputation 9 mo. later
11	1938	Wolfort and Sloane[20]	57	F	Junction middle lower thirds, left	Contusion	None	Swelling, 19 mo.; pain, 4 mo.	Excision	Recurred in 16 mo.; resected; no further recurrence 47 mo. after first operation
12	1938	Wolfort and Sloane[20]	18	F	Lower half, right	Abrasion	3⅔ yr.	Pain, 4 mo.	Curettage, radium	Recurred; resected 13 mo. later; recurred again, amputated after 12 mo.
13	1939	Thomas[19]	19	F	Upper right	None	None	Swelling, 7 yr., pathologic fracture	Curettage, graft	Recurred; amputated 8 mo. later
14	1939	Rankin[14]	25	M	Lower left	Puncture wound	1 yr.	Pain, swelling, 1½ yr.	Curettage	Recurred; resected 15 mo. later; no recurrence 2 yr. after first operation
15	1939	Hebbel	11	F	Lower right	None	None	Pain, swelling, 4 mo.	Curettage	Recurred; recuretted 15 mo. later; again recurred; amputated 2½ yr. after onset

TABLE I

SUMMARIZED CASES OF TIBIAL ADAMANTINOMA

NO.	YEAR	AUTHOR	AGE	SEX	SITE	ANTECEDENT TRAUMA	LATENT PERIOD	CHARACTER AND DURATION OF SYMPTOMS	INITIAL THERAPY	SUBSEQUENT COURSE
1	1913	Fischer[6]	37	M	Junction lower middle thirds, left	Contusion	5 mo.	Pain, swelling, 5 mo.	Resection, bone graft	No recurrence, 8 mo. later
2	1930	Richter[16]	12	M	Middle third, left	Fall	?	Swelling, 8 mo.	Amputation	Uneventful
3	1931	Baker and Hawksley[1]	46	M	Lower third, left	Contusion Contusion	8½ mo. 1½ mo.	Pain, swelling, 6 wk.	Resection, bone graft	No recurrence, 2 mo. later
4	1932	Ryrie[17]	52	M	Middle third	Contusion	8 yr.	Swelling, 8 yr.	Curettage	Recurred, amputated 6 mo. later
5	1933	Petrov and Glasunow[13]	22	M	Middle third, left	None	None	Swelling, 3 yr.	Resection, bone graft	No recurrence, 1 yr. later
6	1934	Holden and Gray[7]	36	F	Lower third, left	Abrasion, contusion ankle	None	Pain, 2 yr.	Excision	Recurred after 2 yr.; re-excised; deep x-ray
7	1937	Bishop[3]	22	M	Upper third, right	Fracture	8 wk.	Swelling, 3 yr.	Curettage, chips, graft	Recurred; amputated after 14 mo.; 4 yr. after fracture
8	1938	Rehbock and Barber[15]	24	F	Lower third, left	Sprain ankle	None	Pain, swelling, 18 mo.	Wide excision	No recurrence 8 mo. later

9	1938	Oberling et al.[11]	51	M	Middle third	?	?	?	Excision	Recurred; amputated 7 mo. later
10	1938	Dunne[4]	32	M	Junction upper middle thirds, left	Contusion, abrasion	9 mo. ±	Swelling, 4 yr.; pain later mo.	Deep x-ray	Progression; amputation 9 mo. later
11	1938	Wolfort and Sloane[20]	57	F	Junction middle lower thirds, left	Contusion	None	Swelling, 19 mo.; pain, 4 mo.	Excision	Recurred in 16 mo.; resected; no further recurrence 47 mo. after first operation
12	1938	Wolfort and Sloane[20]	18	F	Lower half, right	Abrasion	3⅔ yr.	Pain, 4 mo.	Curettage, radium	Recurred; resected 13 mo. later; recurred again, amputated after 12 mo.
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14	1939	Rankin[14]	25	M	Lower left	Puncture wound	1 yr.	Pain, swelling, 1½ yr.	Curettage	Recurred; resected 15 mo. later; no recurrence 2 yr. after first operation
15	1939	Hebbel	14	F	Lower right	None	None	Pain, swelling, 4 mo.	Curettage	Recurred; recuretted 15 mo. later; again recurred; amputated 2½ yr. after onset

bundles of spindle cells were exclusively presented in the biopsy examined during the exploratory operation in our case and an erroneous diagnosis of sarcoma was made at that time. This possible morphologic variation must be considered in the examination of biopsies.

HISTOGENESIS

The histogenesis of tibial adamantinoma is yet a matter of speculation. While most observers consider it to be an epithelial tumor, there are two opposing explanations of its origin. Fischer[6] believed that it has its origin in a rest resulting from a downgrowth of the ectoderm to reach the bone. To explain the organoid structure of the tumor, he further contended that the differentiating capacity of the oral ectoderm is shared by the general ectoderm so that a rest laid down at the time of formation of the enamel organ retains a specialized growth capacity and in neoplasia assumes the structure of adamantinoma. Ryrie[17] completely discarded Fischer's theory and attempted to explain its origin entirely on the basis of trauma. He believed that at the time of an injury cutaneous epithelial appendages, such as hair follicles, may be implanted into the periosteum and, as a result of "thwarted repair," undergo neoplasia. He considered the intimate relationship of the skin and tibial periosteum to favor such implantation by trauma even in the absence of a break in the continuity of the skin. He further emphasized the basal-cell character of the tumor and doubted the justification for the name adamantinoma. Richter,[16] although recognizing the morphologic similarity of his tumor to that previously described by Fischer, believed it to be of endothelial origin and called it "adamantinoma-like." It may be noted here that Simon[18] illustrates as endothelioma of the tibia a tumor of the same morphology which undoubtedly belongs to this group. Such interpretations may well contribute to the apparent rarity of the tumor.

In reference to the suggested traumatic origin for this tumor the several case histories relative to the question of antecedent injury are deserving of detailed consideration. In 11 of the cases summarized in Table I a history of some type of injury is given. In 4 (Cases 1, 3, 10, and 14) the original injury healed without sequelae. In Case 2, although a history of injury was given, its character and time relationship to the onset of symptoms were unknown. In Cases 4 and 12 slight tenderness was said to have persisted at the site of the injury until the onset of the tumor eight and three and two-thirds years later respectively. In Case 7 swelling began subsequent to the removal of a cast eight weeks after a fracture. In Cases 8 and 11 pain and swelling persisted after a sprain and a contusion of the ankle respectively. In Case 6 pain, which had already been irregularly present for some time, became more severe and more constant following a contusion and abrasion of the ankle.

It is evident from a consideration of these data that strict application of the usually accepted conditions necessary to establish the traumatic origin of a tumor[2] cannot be fulfilled. In no instance is the previous integrity of the tissues assured. There is lack of continuity of symptoms in several of the cases. In at least 1 case the latent period is unreasonably long and in another very short. The injury aggravated symptoms already present in 1 case and in another a sprain of the ankle followed by persistent symptoms is more logically considered coincidental. Antecedent trauma is definitely denied in 2 cases (Cases 5 and 14) and is presumably absent (no history of injury given) in another (Case 13). Absence of antecedent injury is a serious objection to the traumatic theory of origin. In such cases adherence to that concept necessitates the assumption of significant but overlooked or forgotten injuries and carries the theory far beyond the limits of reasonable application. It may be concluded that, for the group as a whole, evidence for a traumatic origin is insufficient.

The present alternative of an untenable traumatic theory of origin is an acceptance of the origin of the tibial adamantinoma from a rest. While this explanation is not unattractive, it must be admitted that information concerning the occurrence of ectodermal rests in relation to the skeletal structures of the extremities is wholly lacking. It is probable that, assuming the existence of a rest, Fischer's concept of specialized differentiation too sharply limits the morphologic possibilities of a tumor derived from such a rest. It is well known that there are wide variations in the microscopic structure of tumors fulfilling the clinical features of maxillary adamantinoma.[5] The craniopharyngeal adamantinoma is but one of the histologic types of tumors derived from remnants of Rathke's pouch, a structure in which no dental apparatus is involved. The one reported ovarian adamantinoma[21] has been logically interpreted as a one-sided development of a teratoma. Kegel[8] emphasizes the basal-cell character of maxillary adamantinoma and, in addition to Ryrie, Petrov and Glasunow[13] particularly emphasize the basal-cell character of tibial adamantinoma. Thus, this tumor may be but one possible structural modification of a primary epithelial tumor of bone. In this connection Petrov and Glasunow cite three cases of apparently primary squamous-cell carcinoma of bone, one in the ulna,[9] and two in the tibia.[10, 12] The evidence for the primary character of these tumors is as good as is the evidence for the primary character of the tibial adamantinoma. The histogenesis of a squamous-cell carcinoma of bone is as obscure as is that of the tibial adamantinoma. It would appear, however, that they are related and that for both histologic types there is a common origin. Thus the tibial adamantinoma would bear the same relationship to the tibial squamous-cell carcinoma as a craniopharyngeal adamantinoma bears to a squamous-cell carcinoma of Rathke's pouch origin.

SUMMARY

The case of a tibial adamantinoma occurring in a 14-year-old girl is described. Fourteen previously reported cases are reviewed.

The histogenesis of tibial adamantinoma is uncertain. Of two explanations given for its origin, it appears that trauma may be eliminated as the etiologic factor, leaving its origin from an ectodermal rest as an insecurely established alternative.

Irrespective of the uncertainty concerning its histogenesis, tibial adamantinoma deserves recognition as an entity. Its clinical features of slow progression and failure to metastasize make it unique among bone tumors. Although rare, it is probable that the tumor has not been encountered as infrequently as the number of reported cases would indicate. The greatest importance attached to its recognition is concerned with the apparent response to therapy in early stages. Curettage is ineffective and a procedure designed to remove completely the tumor offers the possibility of cure at a stage before it has progressed to a point where amputation is imperative.

Thanks are due Dr. W. H. Cole and Dr. L. G. Rigler of the Departments of Orthopedics and Radiology, respectively, of the University of Minnesota Hospitals for permission to use the clinical records and the roentgenograms of the case reported here.

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INCREASED COLLATERAL BLOOD SUPPLY TO THE KIDNEY IN RENAL HYPERTENSION*†

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THE production of persistent hypertension by chronic renal ischemia[1] suggested to us, as it has to several other workers,[2-5] that an increase in the collateral blood supply to the ischemic kidney might relieve the ischemia and possibly the hypertension. This thesis was tested in eighteen dogs. The efficacy of the collateral supply was judged by the effect upon the course of the hypertension and by the anatomical evidence of cortical vascularity.

Blood pressures were obtained with the Hamilton needle manometer[6] on trained, unanesthetized dogs, according to the method previously described by us.[7] All the operations were carried out under nembutal anesthesia with aseptic technique. The kidneys were decapsulated and brought into close contact with the denuded posterior and lateral muscle walls (myopexy) in order to facilitate the development of a collateral blood supply either before or after the development of the hypertension. The Goldblatt technique[1] was used to produce the hypertension.

At the termination of each experiment, the dog was anesthetized with nembutal, the renal arteries ligated, and India ink injected into the thoracic aorta. The animal was sacrificed within a few minutes. The kidneys were then examined to determine the extent of the collateral blood supply, as indicated by the amount of the India ink which had entered the kidney.

Group 1.—(a) In two normotensive dogs simple unilateral decapsulation was performed. A month later India-ink injection showed no demonstrable difference in the amount of ink in the operated and unoperated kidneys. (b) In two normotensive dogs the omentum was brought in contact with a decapsulated kidney. A month later India-ink injection showed a slightly greater amount of India ink in the operated kidneys than in the unoperated ones. (c) Unilateral decapsulation with the production of a muscle bed was performed in four normotensive dogs. A month later the India-ink injection showed approximately twice as much India ink in the decapsulated kidney as in the unoperated kidney. At autopsy it was observed that an adherent scar tissue capsule completely surrounded each of the decapsulated kidneys.

*Aided by the A. D. Nast Fund for Cardiac Research.

†Presented in preliminary form at the Central Society for Clinical Research, Chicago, Ill., November, 1939.

Received for publication, December 1, 1939.

SUMMARY

The case of a tibial adamantinoma occurring in a 14-year-old girl is described. Fourteen previously reported cases are reviewed.

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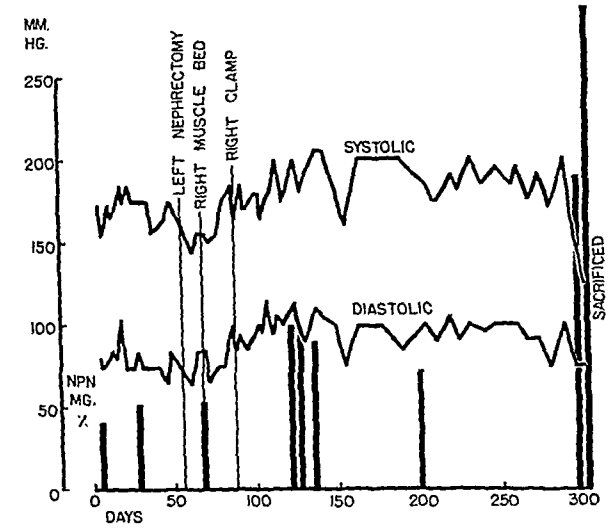


Fig. 2.—(Dog U-21.) The effect of decapsulation and myopexy on the action of subsequent constriction of its renal artery. The left kidney had been removed at an earlier operation. Twenty-one days after decapsulation and the application of a muscle bed to the right kidney, a Goldblatt clamp was applied to the renal artery. Hypertension as well as renal excretory insufficiency developed following this last procedure; these persisted with a terminal increase in the latter, leading to a marked uremia 211 days later, at which time the animal was sacrificed. At necropsy, the India-ink injection made ante mortem revealed a good collateral blood supply through the cortex from the perirenal adhesions. An extensive scar encompassed the kidney. Conventions are the same as in Fig. 1.

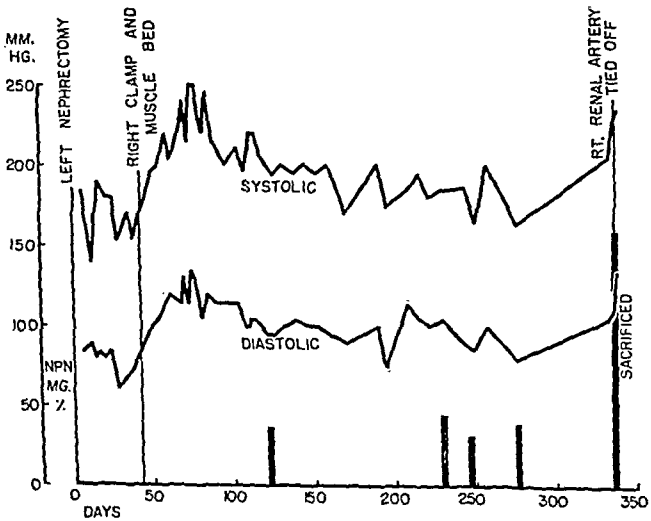


Fig. 3.—(Dog K-7.) The effect of a decapsulation and myopexy simultaneously with a partial constriction of its renal artery. The left kidney had been removed in an earlier operation. The combined operations on the right kidney resulted in hypertension, which was most marked soon after the operation, as is often the case in animals even when no myopexy and decapsulation are done. The right renal artery was completely tied off 293 days after the operation, and it was found that the collateral blood supply was not sufficient to prevent a further elevation of pressure and the development of uremia. The animal was sacrificed 3 days after the complete renal artery ligation. At necropsy, the India-ink injection made *ante mortem* demonstrated the presence of a good collateral blood supply through the cortex from the perirenal adhesions. An extensive thick scar encompassed the kidney. Conventions are the same as in Fig. 1.

Group 2.—In three dogs with hypertension of 169, 79, and 39 days' duration, decapsulation and the production of a muscle bed for the ischemic kidneys caused only a transient fall in blood pressure. Fig. 1 shows the protocol of the last animal. However, the blood pressures returned to the hypertensive levels within three to twenty days, and these elevated pressures were maintained until the dogs were sacrificed 267, 81, and 96 days later, respectively. In one of these animals the main renal arteries were tied off completely 220 days after the muscle-bed operation. Unlike the effect in kidneys without a muscle bed, renal excretory insufficiency did not develop; however, the blood pressure mounted to higher levels and the animal was sacrificed 47 days later. As in the normotensive dogs of Group 1, India-ink injection in these three animals showed the development of an extensive collateral circulation, and adherent scar tissue capsules completely surrounded the decapsulated kidneys.

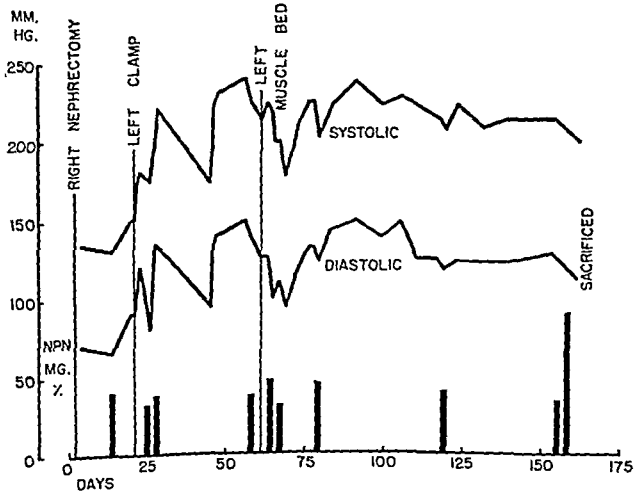


Fig. 1.—(Dog U-84.) The effect of decapsulation and myopexy on a pre-existing renal hypertension. The right kidney had been removed some days previous to the application of a Goldblatt clamp to the left renal artery. Hypertension followed the latter operation. The production of a muscle bed after decapsulating this kidney 41 days later had only a transient depressor effect. Hypertension then persisted for 96 days until the animal was sacrificed. Note the late development of an elevation of the blood N.P.N. At necropsy, the India-ink injection made ante mortem demonstrated the presence of a good collateral blood supply through the cortex from the perirenal adhesions. An extensive thick scar encompassed the kidney. In the figure the blood pressure is shown by curves, the systolic above and the diastolic below. The blood N.P.N. values are given by the height of the vertical blocks, and the time at which various procedures were carried out are shown by vertical lines. Zero time is taken as the time when the animal had been properly trained.

Group 3.—The prophylactic effect of the production of a collateral blood supply previous to the renal arterial clamping was studied in six dogs. In five, decapsulation and the production of a muscle bed were performed about one month before the establishment of renal ischemia. The protocol of one of these animals is shown in Fig. 2. In a uninephrectomized dog the muscle bed and the Goldblatt clamp were simultaneously applied to the remaining kidney (Fig. 3). Hyperten-

rison[14] advocated renal decapsulation in order to increase the blood supply to the kidneys in Bright's disease. This procedure has since been used sporadically for many renal disorders and the reports are in disagreement as to its value. Our results indicate that when "improvement" occurred, it was of a temporary nature.

Several investigators are at present engaged in the attempt to produce an increased blood supply to the kidneys by various means. Cerqua and Samaan[2] have reported the cure of experimental renal hypertension by renal decapsulation and the establishment of intimate contact between the denuded areas and the spleen and the omentum. These workers showed that within a few days the blood pressure had returned to normal levels. Inspection of the kidney at this time showed well-developed blood vessels traversing the area between the decapsulated kidney and the omentum. At this time, surgical destruction of the collaterals resulted in a return to the hypertensive levels. This picture is similar to that which we have found, except that in our experiments the destruction of the collateral supply came about spontaneously with the growth and development of the scar tissue capsule.

Davis and Tullis[3] have recently reported their observations on the development of a large collateral blood supply by splitting the kidney and sewing in a portion of the omentum. MacNider and Donnelly[4] introduced omentum into a cortical slit and found that a considerable area of renal tissue received blood from this adventitious source. Mansfield, Weeks, Steiner, and Victor[5] reported that omentum-kidney pexis resulted in a temporary fall in the blood pressure of hypertensive dogs. However, spleen-kidney pexis was followed by a continuous decline to normal pressure lasting up to six months. Langeron and Camelot[15] have reported that renal decapsulation in five clinical cases of grave hypertension resulted in a transient fall in blood pressure lasting for only a few days, the blood pressure then returning to the previous level. Abrami, Isélin and Robert-Wallich[16] performed unilateral decapsulation and brought omental tissue into close contact with the denuded kidney in two clinical cases of renal hypertension but found no change in blood pressure. Bruger and Carter[17] have utilized a similar procedure. De Takats[18] found no improvement after such an operation. Thus, decapsulation with or without the production of a muscle bed or omental graft results in only an evanescent fall in blood pressure and fails to correct renal hypertension. The spleen-kidney pexis may offer better possibilities, but further investigation on this point is essential.

It should be kept in mind that the Goldblatt dog provides an animal on which the search for a method of alleviation of clinical hypertension is limited to that form which is due to partial occlusion of the main renal arteries. However, in the great majority of cases in man,

sion developed in all except one of these animals, which is similar to our experience in producing hypertension without a muscle bed. In one other dog decapsulation and myopexy appeared to lead to hypertension, even without the application of the Goldblatt clamp. In this series India-ink injection showed the presence of numerous functioning capsular-cortical blood vessels, but scar tissue capsules completely surrounded the decapsulated kidneys.

The natural tendency for the blood pressure to return to normal in hypertensive dogs with renal ischemia without special procedures to bring this about has been observed in our laboratory[7] and has been the subject of reports by other investigators.[8] This disappearance or partial alleviation of the hypertension has been associated with the development of large collateral blood vessels entering the capsule and pelvis of the ischemic kidney. The newly developed accessory circulation may be sufficient to permit the kidney to carry on its function even after progressive and complete obliteration of the main renal arteries.

In view of the large accessory blood supply which is developed without aid by an ischemic kidney, decapsulation and myopexy might be expected to result in an even greater collateral supply and thereby facilitate the relief of the ischemia and possibly the hypertension. The statement of Goldblatt[9] that renal decapsulation with myo- or omentopexy may interfere with the pronounced elevation of the blood pressure in experimental renal ischemia might be so interpreted. Our results show definitely that this is not the case. Although a demonstrable accessory supply through the cortex does develop and may neutralize the tendency toward renal excretory insufficiency, the formation of a scar-tissue capsule to take the place of the natural capsule which has been stripped off appears to prevent the development of sufficient adventitious blood vessels to relieve the ischemia. The tendency of this fibrous capsule to shrink, its relative lack of distensibility when compared to the natural capsule, and its close adherence to the cortex of the kidney all serve to place the decapsulated kidney at a disadvantage.[10] Further, envelopment of the kidney in a relatively inflexible capsule interfering with the normal fluctuations in kidney volume which occur during the cardiac cycle may lead to anuria[11] or even to hypertension.[12] Slight increases in the intrarenal pressure, which might be brought about by the rigid capsule, also could seriously interfere with the blood supply to the kidney.[13]

The temporary depression of arterial blood pressure observed in hypertensive dogs after renal decapsulation may be attributed to the rapid and extensive development of a collateral blood supply to the kidney. The gradual return to the previous pressure level suggests that, as the scar tissue capsule forms, it destroys a portion of the newly developed collateral supply. It is almost fifty years since Har-

TRANSPLANTATION OF THE LOWER SCAPULA WITHIN THE THORACIC CAGE FOLLOWING UPPER THORACOPLASTIES

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THE role played by the scapula in its relationship to the results following thoracoplasties has been well recognized for some time.

As early as 1910 the scapula was used by Adams[1] to occupy the place of the excised ribs in a successful attempt to obliterate an empyemic cavity. This same author in 1918[2] utilized the scapula again by pushing it into the empyemic cavity following resection of the ribs over a large chronic empyemic cavity. Steinke and Villani[8] resected the medial portion of the scapula for fixation and pain following thoracoplasty for pulmonary tuberculosis. Coryllos[5] mentioned a similar procedure for mobilization of an anchored scapula. Steinke[9] feels that the use of a pressure pad postoperatively, causing the scapula to become fixed in a depressed position, is an adjunct in the collapse of the cavity.

Holman[6] feels that the scapula is the greatest obstacle in obtaining the most beneficial results in partial thoracoplasty for apical tuberculous abscesses. He makes the observation that is so familiar to thoracic surgeons; namely, that, following the resection of five ribs, the scapula prevents satisfactory falling in of the posterior thoracic wall. Following removal of six ribs there is likely to be pain as the lower angle of the scapula passes back and forth over the seventh rib. He further mentions that resection of seven ribs might prove too formidable a procedure and that the reduced vital capacity with the additional sacrifice of a good lung might prove unwarranted, when the object is closure of an apical cavity. As a substitute for resection of the sixth and seventh ribs, he recommends a one- or two-stage operation which accomplishes complete removal of the upper three ribs and the posterior third of the fourth and fifth ribs. Following this the lower third of the scapula is resected. Holman suggests that falling in of the small scapula might even be preventive of paradoxical respiration. However, he reserves his final observation on this point.

Lilienthal[7] expressed the preference for removal of another rib rather than resection of a portion of the scapula. Bettman[4] agrees with Lilienthal in this viewpoint, but feels that a portion of the scapula should be removed when fixation exists.

Alexander[3] states that, when the entire scapula drops into the thoracic wall defect, resulting from the rib resection, there is a much

Received for publication, December 8, 1939.

the symptom of hypertension is associated with partial occlusion of the renal arterioles rather than of the main renal arteries. Thus, an accessory blood supply to the kidney which might relieve the Goldblatt type of hypertension would not necessarily relieve hypertension in man. However, since the method which we describe does not alleviate even the Goldblatt type, its use on man is obviously unjustified as yet.

SUMMARY

Decapsulation and the production of a muscle bed for the ischemic kidneys in hypertensive dogs leads to a temporary fall in blood pressure, followed by a return to the hypertensive level within a few days. In normal dogs the procedure does not prevent the development of hypertension if the renal arteries are subsequently partially occluded.

There appears to be no evidence warranting the use of this procedure for the relief of hypertension in man.

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when an anterior thoracoplasty has been performed in addition to the paravertebral resection of the ribs. In reoperating upon these cases for the third stage when indicated, we find a large bursa-like sac beneath the scapula. This is lined with a glistening membrane, which, on section, shows a hyalinized connective tissue. This very closely resembles the lining of an extrapleural pneumothorax cavity and lies between the anterior surface of the scapula and the tissues beneath, which usually consist of regenerated ribs.

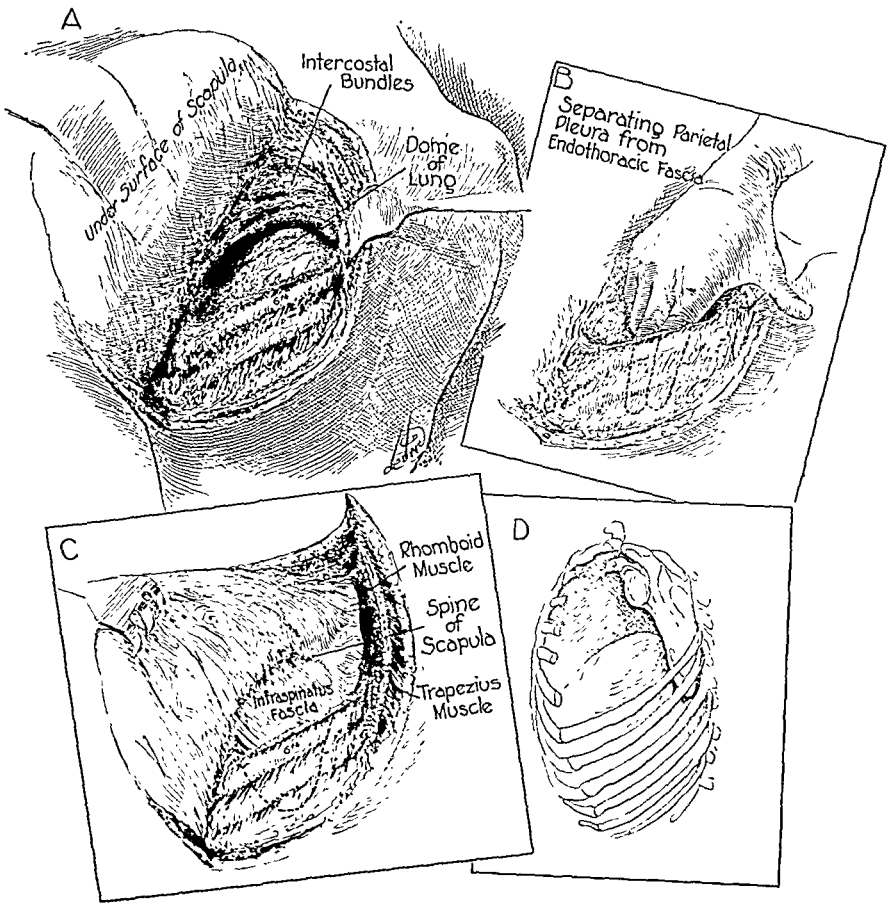


Fig. 1.—*A*, Second stage paravertebral thoracoplasty with removal of the upper five ribs and apicolysis; *B*, separation of the parietal pleura from the endothoracic fascia to develop a pocket for the lower portion of the scapula; *C*, soft tissues separated down to the infraspinatus fascia and the lower one-third of the scapula transplanted inside of the ribs into the pocket previously developed; *D*, diagrammatic sketch showing the position of the transplanted scapula.

There was a recent case that had an apical cavity at the level of the fourth rib posteriorly and in which pneumothorax had not been successful because of apical adhesions. Following division of many of these adhesions by closed pneumonolysis, the collapse was still inade-

better permanent collapse than when only the upper portion of the scapula tilts into the defect; he also believes that retention of the sixth and seventh ribs occasionally allows the angle to slip in and out, causing pain. He notes that, if the lower end of the scapula becomes caught within the concavity of the sixth or seventh rib, a high shoulder position producing scoliosis would probably result. He mentions an instance that occurred in one of his patients where, following resection of the upper four ribs, the scapula moved forward and the inferior angle slipped over the fifth rib and became locked in this position. This individual presented a very high shoulder until the fifth and sixth ribs were removed at a subsequent stage. Alexander feels that the angle of the scapula occasionally slips over and rests upon the intercostal muscles within the curve of the ribs and attributes the higher than normal shoulder position to this fact. The procedure he uses is subperiosteal resection of the lower portion of the scapula, with destruction of the osteogenic function of the periosteum with 10 per cent formalin. He advises against removal of too large a portion so that the remaining scapula can fall into the costal defect. It is his opinion that an eight-rib thoracoplasty is frequently necessary unless this resection is done and that it must be decided in each particular case whether as many as eight ribs should be removed or whether the lower portion of the scapula should be resected.

Over a period covering the past five years we have used a procedure in fifty cases which seems to overcome the difficulties mentioned regarding the scapula in upper thoracoplasties. In addition to this we feel that it gives added compression to the lung and in certain instances precludes the necessity of another stage. Some cases, where it seemed likely that three stages would be necessary, have had cavity closures when the scapula was transplanted at the second stage. Our treatment of the scapula is as follows:

After removal of the ribs at the second stage, the skin and subcutaneous tissue are separated from the fascia over the infraspinatus muscle from the angle up to the spine of the scapula. There is a definite plane of cleavage which is developed practically without any bleeding. Next, the lung is very readily separated posteriorly from the thoracic cage extrapleurally over the uppermost ribs, which are usually the fifth, sixth, and seventh, and a pocket developed in this manner. The lower portion of the scapula is placed into this space; then the trapezius, rhomboids, and latissimus dorsi muscles are reunited and the skin is closed without drainage, just as in the routine thoracoplasty. There has been no interference with shoulder function in the cases that were exercised early postoperatively. In some instances the scapula has dropped so far anteriorly that a definite shelf exists and one's fingers can be hooked over between the uppermost rib and the body of the scapula. This feature is particularly noticeable

when an anterior thoracoplasty has been performed in addition to the paravertebral resection of the ribs. In reoperating upon these cases for the third stage when indicated, we find a large bursa-like sac beneath the scapula. This is lined with a glistening membrane, which, on section, shows a hyalinized connective tissue. This very closely resembles the lining of an extrapleural pneumothorax cavity and lies between the anterior surface of the scapula and the tissues beneath, which usually consist of regenerated ribs.

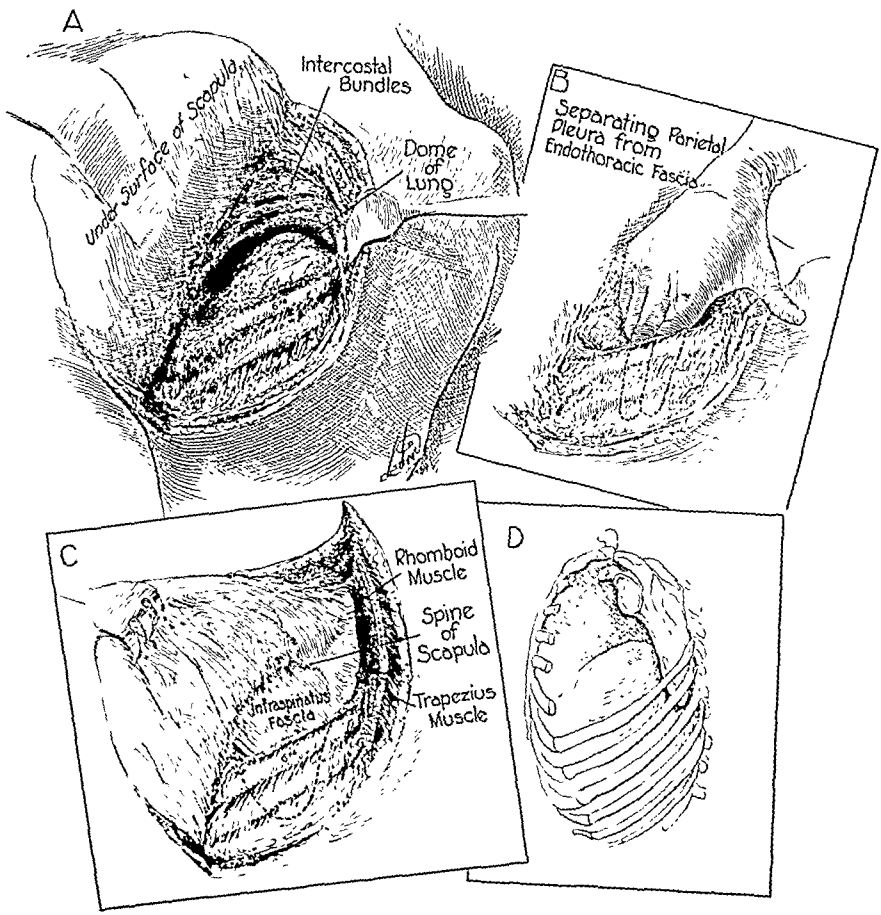


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There was a recent case that had an apical cavity at the level of the fourth rib posteriorly and in which pneumothorax had not been successful because of apical adhesions. Following division of many of these adhesions by closed pneumonolysis, the collapse was still inade-

quate and thoracoplasty was recommended. It was decided that two stages would be necessary to compress the lesion sufficiently. At the time of the thoracoplasty on Aug. 21, 1939, following removal of the

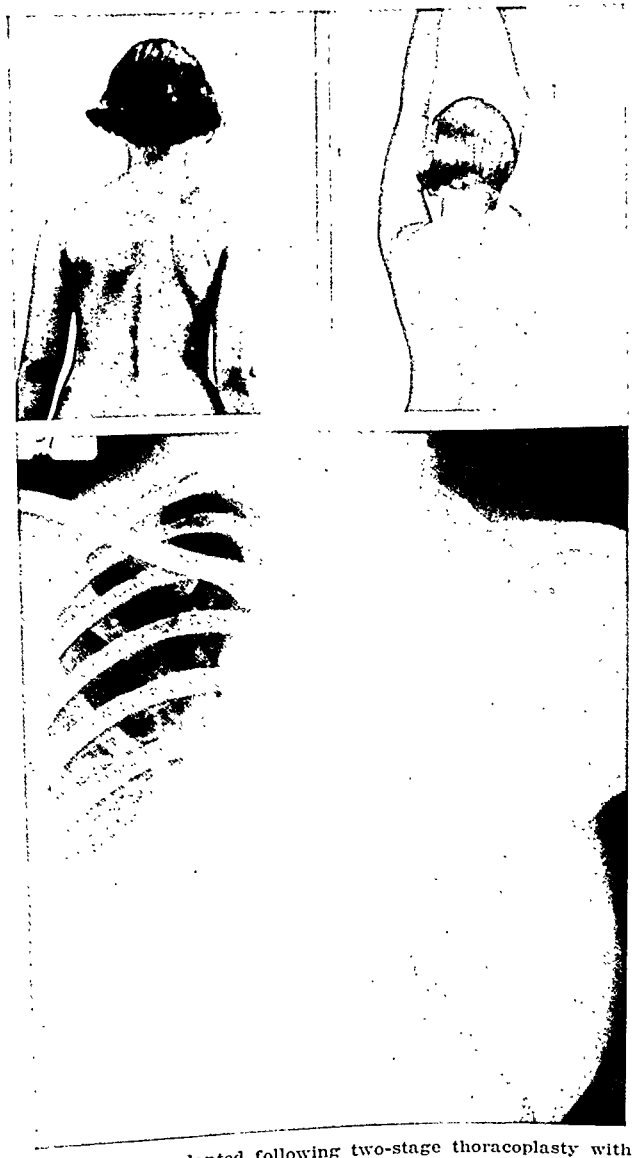


Fig. 2.—The scapula transplanted following two-stage thoracoplasty with removal of the upper five ribs.

upper three ribs, the mediastinum was very stable and, as the patient was in no way upset by the procedure, it was decided to remove the posterior half of the fourth rib, develop a pocket between the parietal pleura and the thoracic cage posteriorly, then free the covering of the

Fig. 3.—Transplanted scapula at second stage after removal of the upper six ribs. This has been combined with an anterior resection of the costal cartilages.

Fig. 4.—Scapula transplanted following the second stage and retransplanted at the time of the third stage, upper seven ribs resected. The angle, instead of snapping back and forth over the uppermost rib, slides back and forth into its pocket laterally.

scapula down to the infraspinatus fascia and transplant the lower portion of the scapula within the thoracic cage. Following this the convalescence was very smooth and physiotherapy about the shoulder was started at the end of a week. Conversion of the sputum took place before two weeks had passed postoperatively and it has remained negative to date. We have felt, as Holman suggests, that falling in of the scapula might be to some degree a preventive of paradoxical respiration. Cases to be subjected to the resection of three and one-half ribs with transplant of the scapula should be selected with the greatest care, as a second stage can be avoided only in carefully chosen instances. We mention this case because it is our opinion that occasionally in favorable cases this procedure might combine first and second stages without added risk to the patient.

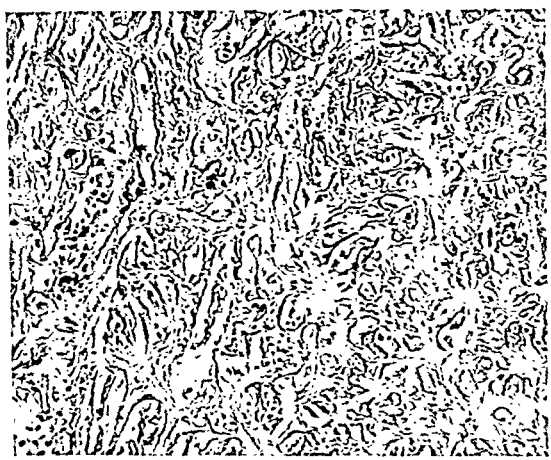


Fig. 5.—Photomicrograph of section removed from sac found in these cases beneath the scapula at the time of reoperation shows hyalinized connective tissue.

It is quite possible that the shoulder is slightly higher in some of our cases, but, as shown in the illustrations, this is not particularly noticeable. If the scapula does lend some support in this manner, we feel it is likely that the degree of scoliosis might be diminished by this mechanism. In answer to Alexander's explanation for the high shoulder occasionally seen in postoperative thoracoplasties, that the angle slips over the uppermost rib and rests upon the intercostal muscles, it is our opinion that the pocket developed between the pleura and the thoracic wall to receive the lower portion of the scapula overcomes this possibility. Winged scapula obviously cannot exist postoperatively in these cases, and, although this is a relatively infrequent complication, it does occur and presents a rather annoying deformity. Motion of the shoulder is not interfered with unless immobilization is maintained for too long a period of time or deep infection occurs.

Fig. 4.—Scapula transplanted following the second stage and retransplanted at the time of the third stage, upper seven ribs resected. The angle, instead of snapping back and forth over the uppermost rib, slides back and forth into its pocket laterally.

A CHRONIC UNDERMINING ULCER OF THE SKIN DUE TO A BETA-HEMOLYTIC STREPTOCOCCUS

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AMONG the many types of chronic ulcerations of the skin, those due to streptococcal infections have only recently been definitely identified.

In 1924 Cullen[1] described a chronic undermining burrowing ulcer of the abdominal wall following drainage of an abdominal abscess. Castellani[2] in 1928 reported the occurrence of lesions beginning as red papules and three or four weeks later developing into abscesses and granulomatous ulcers, connected by sinus tracts. From these lesions he obtained organisms which he believed to be atypical streptococci. Hamilton[3] in 1931 reported cases of chronic ulceration of the skin occurring a few days after trauma. The lesions showed punched out or slightly rolled over edges or rapidly forming ulcers with undermined edges, which he concluded resembled Castellani's cases.

Meleney[4] in 1935 reported the occurrence of indolent ulceration of the skin, usually appearing at the site of slight trauma an incised furuncle or in a surgical incision, usually following an operation on the gastroenteric tract or vagina. In these cases the skin margin was undermined rapidly at first and the skin edges became rolled in. Gangrene did not occur, but liquefaction of the subcutaneous fat and connective tissue took place. The adjacent skin had a dull red or bluish-red hue. Biopsy revealed nonspecific inflammatory tissue. The subsequent course was usually characterized by further undermining and ulceration of the skin at a distance from the original lesion, with a sinus connecting the two. The process often showed improvement, only to regress to its former state. Up to the time of Meleney's report, no therapy had been particularly effective, although some of the lesions healed spontaneously. The course was prolonged, often for several years, and in many cases, when the lesions occupied a large area, the patient became weaker and death occurred through septicemia, hemorrhage, or generalized deposit of amyloid. In the milder cases the course, though prolonged, led to eventual healing under surgical therapy and the use of antiseptics. For local treatment Meleney[4] has used a preparation of zinc peroxide with great success. Since his reports have appeared, others have also obtained beneficial results with zinc peroxide in similar conditions.[5-8]

Received for publication, December 15, 1939.

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the human vagina and gastroenteric tract. The organisms which Meleney isolated sometimes have been strictly anaerobic, but many grew both aerobically and anaerobically, the colonies being larger and hemolysis being more extensive under the latter conditions. He states[4] that the hemolytic streptococci may be converted into green-producing streptococci; either in vivo or in vitro and under suitable conditions reversion to the former state may occur.

Up to the present writing, no exhaustive biological, biochemical, or serological tests have appeared. It is one of the purposes of this paper to present the characteristics exhibited by the organism isolated from our case.

CASE REPORT

On Sept. 14, 1938, the patient, a 20-year-old white male, dropped a packing case on his left foot. This trauma was followed by the appearance of a vesicle at the base of the left fifth toe. Ten days later he injured his foot again and shortly thereafter developed a cellulitis on the dorsum of the foot, which was incised and drained. The cellulitis subsided promptly, but an ulceration persisted at the site of drainage. The ulcer was treated by different local antiseptics and later by superficial roentgen therapy. In spite of all therapeutic efforts the lesion remained undermined and epithelization would progress for a time, only to break down again.

On Feb. 23, 1939, he was sent into Lakeside Hospital. Examination revealed an irregular undermined ulceration on the dorsum of the left foot just proximal to the fifth metacarpophalangeal joint measuring 4.5 by 2 cm. The ulceration was surrounded for about 1.5 cm. by an area of bluish-brown discoloration. The edges of the skin were raised and rolled over. The base consisted of purulent exuberant granulations. No other physical abnormalities were found; the temperature was normal. The white blood count was 15,000, 79 per cent of which were polymorphonuclear leucocytes. The Kline exclusion test was negative.

For the first thirty-eight hospital days, the lesion was treated with aloes vera leaf with alternating epithelization and regression. A biopsy was then taken and an ulcer of skin was reported with extensive chronic and acute inflammation. Cultures showed a beta-hemolytic streptococcus, the characteristics of which will be discussed in detail later. The patient was placed on zinc peroxide dressings and within twenty-four hours the lesion became cleaner and showed less undermining; this improvement continued. On the forty-second hospital day, sulfanilamide was started and was continued until discharge, the patient receiving a total dosage of 48 Gm. On the forty-second hospital day, culture of the lesion was sterile. The exuberant granulation subsided and epithelization was complete on the fifty-sixth hospital day and has remained so.

Characteristics of Organism Isolated.—The organism was a gram-positive coccus, occurring in diplococcus form and with short chains on direct smear from the lesion; when first isolated in pure culture in broth medium the chains were long. On repeated subculture the long chains persisted but the size of the coccus was greatly reduced.

It did not grow at 10 or 45° C. Growth was accelerated by the presence of horse or human serum, ascitic fluid, and meat extract. It grew both aerobically and anaerobically, the colonies being larger and having wider zones of hemolysis under anaerobic conditions. It did not grow in 40 per cent bile-blood agar.

On solid media the colonies were pin point in size, opaque, grayish white, raised, circular with slightly irregular margins and granular surface. The colonies were discrete and they emulsified easily. On blood agar there were moderate-sized zones of hemolysis in twenty-four hours, being larger at the end of forty-eight hours.

Meleney and Johnson[5, 6] outline a specific procedure to be followed in the treatment. Zinc peroxide, the active ingredient of a fine white powder containing zinc peroxide, 45 to 50 per cent; zinc hydroxide, 35 to 40 per cent; and zinc carbonate, 10 to 15 per cent, is sterilized in lots of 10 to 50 Gm. by heating to 140° C. for four hours. Before each application the powder is mixed with enough distilled water to make a creamy suspension and then applied liberally so that it reaches the depths of the wound; in certain instances of extensive lesions gauze wet with the material may be used to fill the large spaces and this is covered with an airtight dressing of petrolatum gauze to prevent drying. In many cases it is necessary to excise the undermined edges in order that all parts of the wound be reached. Dressings are changed daily, the encrusted materials from the previous dressing being washed out with saline solution. It is most important to use an active preparation of zinc peroxide and Meleney and Johnson[5, 6] describe a simple test which should be performed upon each new batch of material. The procedure for the test is as follows: A 10 per cent (by weight) suspension is made in distilled water and allowed to stand. The active material assumes a soft flocculent state, and rapidly (within a few minutes) begins to settle, leaving a clear, supernatant liquid. Within one hour bubbles of oxygen arise and continue to do so for twenty-four hours. Samples of inactive or relatively inactive zinc peroxide show slower settling, discharge oxygen with a longer lag period, and provide less of the gas in twenty-four hours. After the evolution of the oxygen, the compounds that remain, namely zinc oxide, zinc hydroxide, and zinc carbonate, are nontoxic and nonirritating to the tissues.

The ulcers treated by Meleney with zinc peroxide exhibited in twenty-four hours a noticeable change, the necrotic exudate at the edges disappearing and the granulation tissue taking on a healthy pink color. Fresh granulations grew in the depths of the lesions and epithelization began. The wounds healed rapidly and in many instances skin grafts were not needed unless the area to be covered was large. Treatment was continued for several days after the surface was epithelized.

The majority of Meleney's work was done before the advent of sulfanilamide and this drug was not used in his reported cases. However, in a footnote in one paper[6] and in a discussion of another[7] Meleney and Johnson state that this drug and prontosil had been used successfully in as yet unreported cases (1937 to 1939). They found that these two drugs were not as effective against microaerophilic hemolytic streptococci as was zinc peroxide, but were useful in cases where local application to all parts of the wound was difficult. Mintz[8] employed sulfanilamide with zinc peroxide in his case with benefit(?).

Meleney[4] thinks that the streptococcus producing the lesion is the same in all cases. He has found that it is similar in many respects to organisms described in the past by other authors who isolated them from

the human vagina and gastroenteric tract. The organisms which Meleney isolated sometimes have been strictly anaerobic, but many grew both aerobically and anaerobically, the colonies being larger and hemolysis being more extensive under the latter conditions. He states[4] that the hemolytic streptococci may be converted into green-producing streptococci; either in vivo or in vitro and under suitable conditions reversion to the former state may occur.

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A soluble hemolysin was formed in liquid media.

In broth the growth at the end of twenty-four hours was evenly distributed and flocculent and was later distributed around the sides of the tube. The growth settled to the bottom in a few days, leaving a clear medium. There was no pellicle formation.

The organism was killed by heating for thirty minutes at 60° C.

Sodium hippurate was not hydrolyzed; methylene-blue milk was not reduced and gelatin and Löffler's medium were not liquefied. The final pH was 5.51. Litmus milk was fermented with retraction of the clot. The organisms were not soluble in bile. Ammonia was formed from peptone. The following sugars were fermented without the production of gas: dextrose, sucrose, lactose, trehalose, and salicin. The following sugars or alcohols were not fermented: inulin, arabinose, raffinose, mannite, and sorbitol.

A subculture of the organism was sent to Dr. George K. Hirst, at the Hospital of the Rockefeller Institute for Medical Research. His report[9] was as follows:

"It (the hemolytic streptococcus) is definitely Group A, but I was unable to place it in any of the Griffith types for which we have serum. These types are 1, 2, 3, 4, 5, 6, 9, 10, 13, 14, 17, 18, 19, 22, 26, 28, 29, 30, and J137." The typing was performed by the precipitin method and slide agglutinations were not done.

One cubic centimeter of a twenty-hour plain broth culture had no visible effect on mice when injected intraperitoneally. Fibrinolysis occurred within three to six hours.

Soluble hemolysin was determined by the method of Hare,[10] fibrinolysis by that of Tillet and Garner,[11] and the fermentation of sugars, sodium hippurate hydolysis, final pH, growth on 40 per cent bile blood agar, and methylene-blue reduction by the methods of Lancefield,[12] with the exception that pH was determined by a hydrogen electrode.

DISCUSSION

The lesion reported here resembles those reported by Cullen, Hamilton, and Meleney in its clinical appearance and course. The cases reported by Castellani differ considerably in their clinical appearance. Since the organism isolated by us can be classified undoubtedly in Lancefield's Group A, its human origin is confirmed. Proof that the human gastro-enteric tract and vagina are the natural habitats is lacking.

Castellani[2] described two organisms, the *Micrococcus myceticus* and the *Micrococcus metamyceticus*.[2] Since the *Micrococcus metamyceticus* was found only in nonfilarial elephantiasis and since the organism was constantly gram-negative and occasionally assumed the form of a cocco-bacillus, it will not be discussed further. The *Micrococcus myceticus* was found to be both gram-negative and gram-positive on smear from the lesion and on culture. The morphology varied, resembling under different conditions at times a diplococcus, at times a streptococcus. In liquid media formation of long chains occurred. It grew poorly on ordinary media, but on repeated subculture luxuriant growth occurred. The colony resembled that of the usual streptococcus. A hemolysin was produced, but there was no liquefaction of serum. The fermentation of sugars was not that of Group A (Lancefield) hemolytic streptococcus. The organism was found to be pathogenic when injected subcutaneously into man and the rabbit.

Hamilton[3] described an organism which he has called *Micrococcus myceticus*. His strain resembled Castellani's in morphology, growth requirements, hemolysin production, and absence of serum liquefaction. The organisms, when grown in broth, produced flocculent growth which settled to the bottom and clung to the sides of the tube in forty-eight to seventy-two hours. On blood agar, the colonies were pin-point size, discrete, grayish white, slightly elevated, round with smooth edges, and produced hemolysis. At room temperature under anaerobic conditions, wider zones of hemolysis were present. Fermentation reactions agreed well with the findings for Group A (Lancefield) hemolytic streptococcus.

It is of interest to note that a short while ago Dr. R. C. Lancefield received a culture of hemolytic streptococci from Dr. J. F. Hamilton of Memphis, Tennessee (author of the articles referred to above[3]), which he isolated from an indolent ulcer similar to our case. Hirst[9] says of this organism:

"It proved also to be Group A, but we were unable to type it. It had the same small colony form and resembled the culture you sent me very closely. . . . I think, and Dr. Lancefield agrees with me, that it is very interesting that the colony of these two organisms appears to be so different from the usual Group A colony."

The fact that (1) this group of lesions due to infection with beta-hemolytic streptococcus is fairly characteristic and (2) the organism isolated by Hamilton is different from others of Group A suggests that this group of lesions might be due specifically to this so far untyped Group A hemolytic streptococcus. To confirm this, several strains from similar lesions should be studied to determine their antigenic characteristics. Neither of these organisms resembles those usually isolated from the throat, blood stream, or cases of puerperal sepsis. The results of further investigation may place them in a distinct subgroup.

SUMMARY

1. A case of chronic undermining ulceration of the skin apparently due to beta-hemolytic streptococcus is reported.

2. The organism grew more luxuriantly under anaerobic conditions and can be definitely classified in Lancefield's Group A, which is of human origin.

3. The lesion responded readily to therapy with zinc peroxide and sulfanilamide.

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TUMORS OF THE MALE BREAST

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ALTHOUGH tumors of the male breast are not frequently encountered, they occur in sufficient number to warrant a further review of their clinical behavior and a report of 35 additional cases.

The first description of cancer of the male breast is attributed to various authors: Franciscus Arcaeus[1] (1494-1573), Thomas Bartholinus[2] (1616-1680), Margagni[3] (1669-1771), and Poirier[4] (1883). Schuchardt[5] in 1886 collected 406 cases of tumor of the male breast, of which 348 were malignant (85.7 per cent). They comprised 2 per cent of all neoplasms affecting the breast. Williams[6] in 1889 analyzed 15,481 primary neoplasms in four London hospitals during a period of sixteen years. Two thousand four hundred twenty-two (15 per cent) occurred in the breast, of which 2,397 were found in females and 25 in males, a ratio of 100 to 1. Of the 25 cases of neoplasm of the male breast, 16 were carcinoma, 3 sarcoma, and 6 benign tumors.

In Deaver and McFarland's series[7] 1½ per cent of the malignant and 2 per cent of the benign tumors of the breast occurred in men. They also state that 20 per cent of all tumors of the male breast are benign and 80 per cent malignant.

Neal[8] studied 117,016 surgical specimens from the diagnostic laboratory of the State Institute for the Study of Malignant Disease, Buffalo, N. Y., and the Laboratory of the Department of Pathology of the University of Missouri. Of the total number of specimens, 9,279 were of the breast. Of this number, 308 were from men and 8,941 from women (sex not ascertained for 30 specimens). Of the 308 male breasts, 60 (19.5 per cent) were malignant and 105 cases (34 per cent) benign tumors. The remaining 143 cases (46.4 per cent) were lesions of other than neoplastic character. These statistics, as the author concludes, are contrary to the general belief that carcinoma is the most frequent lesion in the male breast. These figures are at variance particularly with those of Cheatle and Cutler, who show the relative frequency of various types of tumors affecting the male breast in Table I which is a composite of various statistics available in the literature.

At the Brooklyn Cancer Institute from 1927 to 1939 (July) there were 831 admissions of neoplasms of the breast. Seven hundred ninety-six (95.8 per cent) occurred in females and 35 (4.2 per cent) in males. Of the total number of breast neoplasms, 761 (91.6 per cent) were malignant and 70 (8.4 per cent) were benign. Of the malignant cases, 13 occurred in males (1.7 per cent); of the benign, 22 (31.4 per cent) occurred in males. The total number of male breast neoplasms was 35.

Received for publication, January 2, 1940.

TABLE I*

Malignant tumors 87.5%	Carcinoma	85.5%
	Sarcoma	2.0%
Benign tumors 12.5%	Fibroadenoma	10.0%
	Cyst	
	Papilloma	1.5%
	Mastitis	

*Rare tumors represented by only one type of tissue, fibroma, myoma, lipoma, chondroma, angioma, myxoma, all comprise 1 per cent.

Thirteen (37.1 per cent) were malignant (12 carcinoma and 1 sarcoma); and 22 (62.9 per cent) were benign (7 fibroadenoma, 12 gynecomastia, 1 papilloma, 1 lipoma, and 1 epidermoid cyst).

MALIGNANT TUMORS

Carcinoma.—Although the statistics of Neal and those of our own are not in conformity with the majority of case reports of the past; namely, that carcinoma is the most common tumor in the male breast, our combined number of cases is relatively too small to warrant any conclusion. Therefore, from the data already available it appears that carcinoma is the most common tumor of the male breast.

Clinically carcinoma of the male breast differs from that of the female breast in many respects. The age incidence is somewhat higher in males than in females. Bryan[9] gives the average age as 60 years; Wainwright,[10] 54.2; Neal, 57.7; Speese,[11] 55. The oldest patient with carcinoma of the breast, 91 years of age, was reported by Lunn.[12] In our own series of 13 cases, the oldest patient was 93 years of age, the youngest 40 years. The average age was 62 years. The youngest case was reported by Blodgett[13] in a boy 12 years of age. Simmons[14] reported a case in a boy 13 years of age; Bryan, in a boy of 15 years of age; Moore, Coley, and Benet,[15] in a boy 12 years of age and another in a boy 19 years of age.

Trauma is a greater contributing factor in male than in female carcinoma of the breast. Bryan gives the incidence of trauma in the female as 13 per cent and as 50 per cent in the male. He presents the case of a 15-year-old boy who was struck on the breast by a golf ball, resulting in carcinoma five months later. Moore's[16] patient developed carcinoma of the right breast following a blow, the lump appearing six weeks after the injury. Rodman[17] mentions one case of a laborer who developed carcinoma of the breast after continuously resting against a shovel handle, and another case of a shoemaker who for years had pressed a last against his breast. Griffith's[18] patient developed endothelioma of the breast after being struck by a horse bit. Murphy's[19] patient was struck in the breast by a bottle thrown from a distance of ten feet, three months previous to the development of carcinoma. Billroth's[20] case developed carcinoma in the scar of a gunshot wound in the nipple received six months previously. Simmons reports a case of a 13-year-old boy

who was struck in the right chest by a baseball bat a year before the discovery of the malignancy. There are several other reports where an injury to the breast was a contributing factor in the development of malignancy. The association of trauma in carcinoma of the male breast as reported in the literature from all sources averages 25 per cent. Three cases (23.1 per cent) in our series gave a history of trauma before developing the disease.

Male patients apply for treatment later in the disease than female patients. Owens and Eisendrath's[21] patient had a nodule in the breast for 25 years. When the breast was removed, it proved to be carcinoma. The duration of time from when the patient first noticed the lump and operation in 4 of Wainwright's cases was 20, 25, 26, and 34 years respectively. According to Moore's[22] observation, in 343 cases the average period of the duration of the tumor was 2.4 years. One of his cases had a tumor for 30 years. which later proved to be scirrhous carcinoma. Commenting further, Moore states: "Nothing was said in the discussion of how long some doctor had known about the tumor before serious attention was given to it." In our own series the average time elapsing from the time the patient first noticed the tumor and admission to the hospital was 3 years. The longest time was 10 years, and the shortest 4 months. Fifty per cent of our patients came to us after the tumor had reached the size of an orange and had begun to ulcerate.

Pain in male breast carcinoma is less frequently present than in the female. Pain was not a prominent symptom in Warfield's and Speese's series. It was frequently entirely lacking in Speed's[23] collection. It was present in only 2 of our cases. The presence of a tumor or abnormal changes in the nipple were the first symptoms that called the patient's attention to the fact that there was something wrong with his breast.

The nipple in male breast carcinoma is more commonly involved than in the female. Wainwright states that the nipple is more apt to be involved because the gland is so small that any growth must of necessity be near enough to the nipple eventually to cause its retraction. Speese and Speed both state that the nipple in male breast carcinoma is involved in one-half of the cases. Cheatle and Cutler state that the most common site of origin of male breast carcinoma is the nipple.

Ulceration of the skin is more common in male breast carcinoma than in female. Of 306 cases collected by Wainwright where ulceration of the skin was recorded, 162 cases (52.9 per cent) were ulcerated. Speese states that 30 per cent of all male breast carcinomas undergo ulceration. In Schuchardt's series of 219 cases, 61 (27.9 per cent) were ulcerated. Ulceration was found in 29 per cent of Gilbert's series and in 35 per cent of Warfield's cases. Ulceration was present in more than one-half of our own cases.

The axillary glands are more commonly involved in male breast carcinoma than in female. Cheatle and Cutler state that 60 per cent of the

cases show involvement of the axillary glands at operation or autopsy. They quote Fessler's statistics as high as 72.7 per cent. Warfield's observation is given as 60 to 65 per cent. In Wainwright's series of 331 cases, 228 cases, or more than two-thirds of the cases noted, had axillary involvement. In our own series 11 (91.7 per cent) had axillary involvement.

Lymphedema of the arm is apparently less common in males than in females. It was present in only 1 of our cases (7.6 per cent). Very little mention of it is made in the literature. If lymphedema of the arm is due to lymphatic obstruction in the axilla, it should be more prevalent in males, as axillary node involvement is more prevalent in males.

Judging from the small number of male breast carcinomas reported in the literature compared with female, general widespread and internal metastasis is comparatively greater in males than in females. In our own series 4 cases (30.8 per cent) had visceral, cerebral or osseous metastasis.

Histologically male breast carcinoma is undistinguishable from that of females. Wainwright studied a collection of slides of 79 cases of male breast carcinoma. The most striking impression he obtained from the study was that the fully developed late cases are not distinguishable from carcinoma in the female breast. He doubts whether any pathologist would suspect that any slide in the collection had not come from the female breast.

The prognosis in male breast carcinoma is not as good as in the female, according to Wainwright, Speese, Judd and Morse,[24] Cheatle and Cutler, Gilbert, and many others. The average duration of survival is from two and one-half to three years.

Although of late some surgeons have abandoned the time-honored radical mastectomy and advocate simple mastectomy followed by x-ray therapy, this method of treatment cannot be applied in male breast carcinoma. According to Wainwright and many others, muscle involvement appears earlier and more frequently in male breast carcinoma than in female. According to Speed: "The thinness of the pectoral fascia in the male, demonstrated by Heidenhain, accounts for the close attachment of the breast tissue to the coverings of the pectoral muscle. A malignant tumor easily breaks through this fascia and invades the muscle via the lymphatics, which run from the breast to and along the fascia. A breast cancer may consequently appear to be freely movable on the underlying muscle and yet be involving it along their microscopic lymphatics. Superficial removal cannot be expected to give a radical cure." Speese shares the same opinion. In a study of 100 cases of carcinoma of the male breast, he found 25 per cent showed invasion of the pectoral muscle and 35 per cent showed invasion of the pectoral fascia.

In addition, if one takes into consideration the facts that metastatic axillary nodes are more resistant to radiation than the primary breast carcinoma and that axillary involvement is so much more prevalent in males than in females, one cannot help concluding that radical mastectomy is the treatment of choice in operable cases of male breast carcinoma, even more so than in female.

Sarcoma.—Sarcoma of the male breast comprises 2 per cent of all tumors that affect the male breast. Geist and Wilensky[25] reviewed the literature from 1858 to 1915 and found 435 cases of sarcoma of the breast; only 9 of these occurred in the male. Fox[26] in 1934 studied 35,000 breasts; 60 of these were sarcomas, and only 2 occurred in males. In our own series of 761 malignant tumors of the breast, only 1 case of sarcoma occurred in a male, none in females.

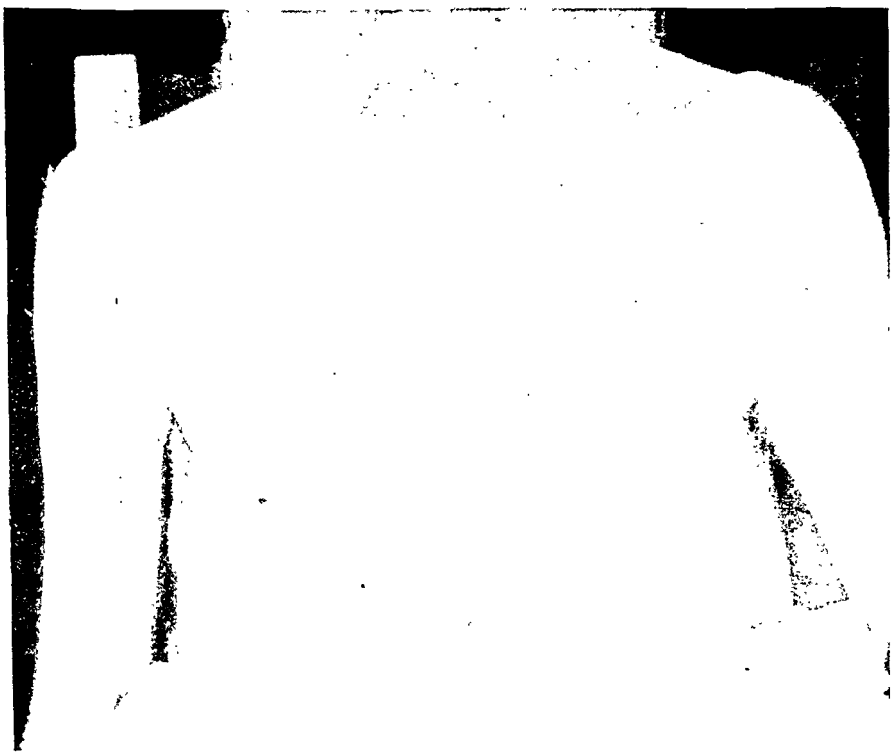


Fig. 1.—Gynecomastia with carcinomatous degeneration in a man 93 years of age.

The age incidence in sarcoma of the male breast is lower than in carcinoma. The average age is given as 45 years (Finsterer,[27] Cheatle and Cutler). Trauma plays a less important role; ulceration is seen less frequently, and the tumor grows more rapidly. It may reach the size of an orange or be as large as a fetal head (Speese).

Histologically, the most common varieties are the spindle-cell (the least malignant), the round-cell, and the melanomatous types. The last

is the most malignant and is believed to arise from a nevus or mole in the skin overlying the breast or the neighboring structures. There are a number of cases reported that originated from a previously benign fibroadenoma.

The course of the disease is much shorter than carcinoma. Finsterer could record but one case of cure. In this there was no recurrence for eleven years.

BENIGN TUMORS

The benign tumors comprise 12.5 per cent of the neoplasms affecting the male breast. The fibroadenoma, gynecomastia, and the cystadenoma or papillary cystadenoma are of the greatest interest to the surgeon.



Fig. 2.—Sebaceous gland carcinoma of the breast of traumatic origin.

Fibroadenoma.—Fibroadenoma is the most common benign tumor found in the male breast. It forms 10 per cent of the tumors that affect the male breast. It is divided, according to Woodyatt,[28] into (a) the sharply circumscribed, firm, dense tumor which occurs without traumatism in the breasts of young men, runs a painful clinical course, and shows under the microscope little or no evidence of inflammation, but all the characteristics of ordinary adenofibromas, such as may be found in the breasts of young women and to which it is analogous; (b) diffuse or ill-defined growths, which may occur at any age as the result

of trauma. They have the same structure as the first type, but in addition inflammatory changes predominate. Cheatle and Cutler do not believe that trauma is a causative factor in fibroadenoma. Their opinion is also shared by Speese. None of our cases gave a history of trauma.

That benign fibroadenomas are subject to malignant changes has been shown by a number of writers. Fox, who made a study of sarcoma of the breast and reported 60 cases in 1934, states: "The belief that many sarcomas of the breast are secondary to benign fibroadenoma is substantiated by the microscopic findings of sarcoma within the substance of a preexisting fibroadenoma in 57 per cent of the cases of fibroadenoma." According to Cheatle and Cutler, a sudden and rapid increase in growth may indicate either a sarcomatous or cystic change in a previously benign tumor.



Fig. 3.—Gynecomastia simulating a female virgin breast just past puberty.

Gynecomastia.—Gynecomastia is an enlargement of the male breast simulating in size and appearance a virgin female breast. In many instances the breast is indistinguishable from that of a female who has just reached puberty. Once gynecomastia takes place, it remains permanently. It is usually bilateral, but unilateral involvement is by no means rare. Increase in the size of the breasts, associated in many instances with pain, are the only symptoms. A whitish discharge from the nipple, sometimes termed "milky," has been reported by some writers.

However, Woodyatt states that there is no case on record in which the secretion of milk has been verified by chemical examination.

Heredity, sexual abnormality, and endocrine disturbances are considered predisposing causes. A number of cases of gynecomastia have been reported following prostatectomy (Mann,[29] Kondoleon,[30] Oppenheimer,[31] and Villeon[32]). One case in our series developed a tumor of the left breast a year following prostatectomy. The tumor proved to be carcinoma. Experimental evidence showing enlargement of the breasts in male animals as a result of induced endocrine imbalance has been shown by Ferguson.[33]

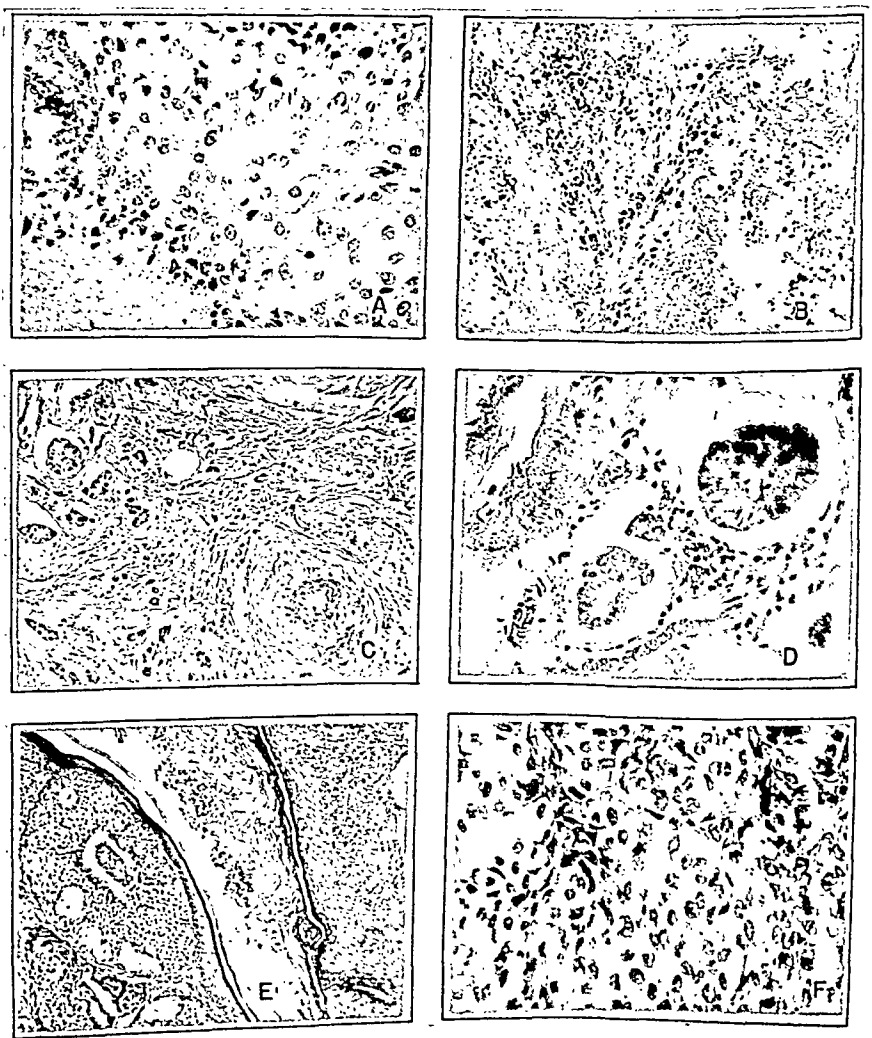


Fig. 4.—Photomicrographs showing: *A* and *B*, melanocarcinoma of the breast; *C* and *D*, adenocarcinoma; *E* and *F*, sebaceous gland carcinoma; and *G* and *H*, gynecomastia with duct papilloma.

Histologically, according to Deaver and McFarland, the breast is characterized by an increase of fibrillar and adipose tissue, marked increase in the number of ducts and tubules, and in a few cases some acini. Von Gusnar[34] examined 106 male breasts at various ages and found that in gynecomastia the connective tissue is only slightly involved, while the glandular tissue shows a marked hyperplasia, and concludes that such breasts are more likely to be the seat of carcinoma.

That gynecomastia is subject to carcinomatous changes is believed by Ewing.[35] He states that unusual development and activity of the male breast are predisposing conditions for cancer. Gynecomastia with carcinoma was found in 9 instances in Gilbert's series of 47 cases of carcinoma of the male breast (19 per cent). One case of gynecomastia with carcinoma was found in our own series (Fig. 1).

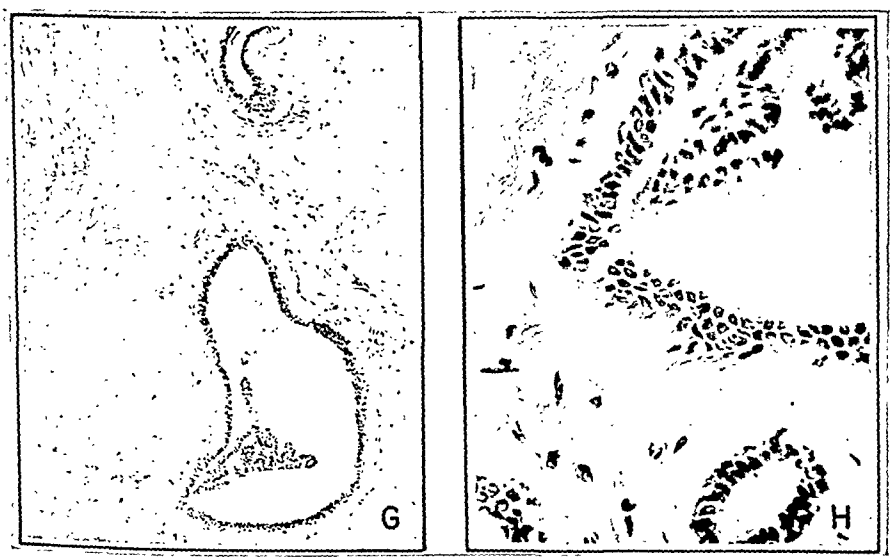


Fig. 4.—See opposite page for legend.

Papillary Cystadenoma.—Papillary cystadenoma comprises 1 per cent of the tumors that affect the male breast. The tumor is slow growing, usually situated near the nipple, well circumscribed, not attached to the skin or pectoral fascia, but may be adherent to the nipple. A "milky" or sanguineous discharge is present, according to David[36] and Cheatle and Cutler in 75 per cent of the cases. According to Deaver and McFarland, a bloody discharge is present in 15 per cent of the cases. In some instances a bloody discharge from the nipple may be present in the absence of a palpable tumor, which is only to be discovered on section or under the microscope. Pain and tenderness are present in 33 per cent of the cases (Cheatle and Cutler).

That papillary cystadenoma of the breast is subject to malignant changes has been recognized by the majority of the writers on this sub-

ject. The frequency of malignant transformation is given as 40 to 50 per cent by Cheatle and Cutler.

After studying the clinical characteristics of benign tumors of the male breast and their tendency to undergo malignant changes, one cannot but conclude that the only treatment for tumors of the male breast is surgical removal of the offending organ.

SUMMARY AND CONCLUSION

1. Tumors of the male breast are uncommon. They comprise 2 per cent of all neoplasms affecting the breast.

2. Eighty per cent (or less) of the tumors of the male breast reported in the literature are malignant, and 20 per cent (or more) are benign.

3. Carcinoma comprises 98 per cent of the malignant tumors of the male breast.

4. Carcinoma in the male breast differs from that in the female in many respects:

A. The age incidence is higher.

B. Trauma is a greater contributing factor.

C. Male patients apply for treatment later in the disease.

D. Pain is a less frequent symptom.

E. The nipple is more commonly involved.

F. Ulceration is more frequently present.

G. The axillary glands are involved in more than one-half of the cases.

H. Lymphedema of the arm is apparently less common.

I. General and widespread metastasis appears to be more frequent.

J. The prognosis is less favorable.

5. Fibroadenoma and gynecomastia comprise 98 per cent of the benign tumors of the male breast.

A. They are subject to malignant transformation, although they may remain dormant for a long time.

B. Simple mastectomy is the treatment of choice, no matter how innocent they appear.

6. Thirty-five additional cases of tumors of the male breast are reported in a series of 831 admissions of neoplasms of the breast to the Brooklyn Cancer Institute.

7. The literature on tumors of the male breast is reviewed and discussed.

8. Our statistics showing the ratio of malignant and benign tumors of the male breast differ greatly from those reported in the literature. However, they approach most closely the series of cases reported from the State Institute for the Study of Malignant Disease, Buffalo, N. Y., and the University of Missouri.

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APPENDICLAUSIS*

Appendical Obstruction Simulating Acute Appendicitis

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IT HAS been the experience of every surgeon to make a diagnosis of acute appendicitis, only to find at operation an apparently normal appendix, without any pathologic explanation for the clinical syndrome. The diagnosis rendered by the pathologic laboratory may be appendix within normal limits, chronic appendicitis, or subacute appendicitis; the last-mentioned diagnosis is usually a compromise between a clinical picture of acute inflammation and the essentially negative pathologic findings.

This apparent error casts no reflection on the physician's diagnostic ability, inasmuch as obstruction of the appendical lumen, a noninflammatory condition of the appendix, closely simulates acute appendicitis.

Years ago numerous authors, particularly the late Van Zwalenburg and Wilkie and, more recently, Wangensteen, have drawn the attention of the medical profession to the importance of obstruction in acute appendicitis. Later, the term appendical colic was introduced to indicate cases in which a fecalith caused painful spasmodic contractions of the appendix, regardless of the presence or absence of an inflammatory process. It is only one step further to the proposal that any type of obstruction of the appendical lumen is capable of giving symptoms of acute appendicitis, even though inflammation fails to develop.

If our findings are confirmed by other investigators, obstruction of the appendix without even microscopic evidence of active inflammation will become a definite disease entity; it might well be called appendiclausis, a term derived from the Latin *claudere*, meaning to bar or to close.

The presentation of the clinicopathologic picture of appendiclausis is based on the study of selected cases from the records of the San Francisco City and County Hospital. Comparison was made with cases of chronic appendicitis and of simple uncomplicated acute appendicitis. Almost 1,000 records were examined, but only clear-cut cases were included in this study. In each case a report of both gross and microscopic examinations of the intact appendix was available. All cases in which the appendix had been opened by the surgeon (a common procedure when the surgeon is puzzled by the unexpectedly normal

*Preliminary report read before the San Francisco County Medical Society on February 8, 1938.
Received for publication, December 22, 1939.

appearance of the organ) and all the clinically or pathologically doubtful cases were discarded. The group thus eliminated comprised all females in whom the onset of pain corresponded to the estimated time of ovulation (whether or not a ruptured Graafian follicle could be demonstrated), all cases in which microscopic examination of the appendix showed even a few solitary neutrophiles in the tissue indicating the beginning of an acute inflammatory process, and all patients in whom concomitant findings (such as mesenteric lymphadenosis, suspicious looking uterine tubes, etc.), might account for the symptoms. Patients with chronic appendicitis who had had a recent aggravation of pain were likewise excluded. One hundred cases of appendiclausis and 100 cases of chronic appendicitis remained; for purposes of comparison, 100 cases of proved acute appendicitis were also surveyed.

Appendiclausis is prevalent. Undoubtedly, a large proportion of the patients with mild acute appendicitis who are treated expectantly and who recover spontaneously actually have appendiclausis. Like acute appendicitis, this disease characteristically affects youth; more than 80 per cent of the cases occur before the age of 30 years. In contradistinction to appendicitis, in my series there were nearly twice as many females as males.

The acute attack of appendiclausis begins with pain, which may be epigastric at first, or general throughout the abdomen, with subsequent localization to the right lower quadrant; or it may be limited to the latter region from the very start. This pain may be cramplike, colicky, stabbing, or constant in character. Contrary to the expectation in obstruction, however, the pain experienced is seldom severe and frequently is no more than an ache. With a few exceptions, it is followed by nausea; vomiting occurs in about one-half the cases, but it is not likely to be persistent or severe. In about 50 per cent of these patients there is no interruption of the bowel rhythm; slightly more than 25 per cent will have had constipation preceding the onset of symptoms, and the rest, a tendency to diarrhea. The temperature may range from normal to 102° F., but it is likely to lie between 99 and 99.5°. The pulse presents a more or less similar variation; occasionally it may be as high as 120, but ordinarily it is in the vicinity of 90.

Localized abdominal tenderness is almost invariably present; only in exceptional cases, however, is it as marked as is typically seen in acute appendicitis. Guarding is present in about two-thirds of the cases, and rigidity more seldom, but both are less pronounced than one usually finds in acute appendicitis. Rebound tenderness, usually mild, is encountered in about one-half the patients; tenderness on rectal examination is elicited a little more frequently.

The white blood count averages 11,000; some patients have no leucocytosis at all; on the other hand, leucocytosis over 15,000 is not un-

common. The percentage of the neutrophiles varies proportionally with the white count; it seldom exceeds 86 per cent, and averages 76 per cent.

The symptoms and the preoperative findings of appendiclausis are identical with those of mild acute appendicitis, and this is the main condition to be considered in the differential diagnosis. All the conditions to be thought of in diagnosing acute appendicitis should be borne in mind, particularly rupture of the Graafian follicle in the female and mesenteric lymphadenosis. The only time the syndrome of appendiclausis can be more or less safely differentiated from acute appendicitis is when the patient is first seen at least two days after the onset of symptoms, which have remained mild; when the abdominal examination is not particularly striking; and when the temperature, pulse, white count, and the percentage of the polymorphonuclear leucocytes remain but slightly elevated, if at all. All of these conditions must be satisfied before acute appendicitis may be excluded. Rupture of the Graafian follicle is to be thought of when the symptoms set in from thirteen to fifteen days before the next regular menstrual period; in this condition the gastrointestinal symptoms, when present, are not prominent, the tenderness is lower, and some tenderness may be elicited on the left side. A diagnosis of acute mesenteric lymphadenosis before operation is hazardous and its differentiation from slightly atypical acute appendicitis unsatisfactory; to distinguish it from appendiclausis is even more difficult.

Obviously, the logical treatment for appendiclausis is appendectomy. The reason for surgical intervention in such an innocuous disease is the ever-present danger of failure to recognize an acutely inflamed appendix, for the price of conservative treatment of acute appendicitis may be too high. In the cases in which acute appendicitis can be excluded with more than reasonable certainty, a patient with appendiclausis may be treated expectantly, but the surgeon must always be on guard against the development of true acute appendicitis.

Most diagnoses of appendiclausis are made at operation. There is no fibrinous exudate covering the appendix, but free fluid, occasionally cloudy, may be encountered; sometimes the quantity of fluid seems to be altogether out of proportion to the other findings. The subserosal appendical vessels are frequently injected, but the appendix is not congested. Obstruction of the appendix is usually easy to recognize. The surgeon often records his observation that the appendix is rigid and edematous; in view of the negative microscopic findings, it seems likely that such rigidity may be caused by the fact that the appendix is packed with fecal matter, rather than by the edema of the wall.

Table I presents the various types of obstruction found in this series as well as a comparison with the incidence of obstruction found in asymptomatic appendices.

TABLE I

INCIDENCE OF OBSTRUCTIVE FACTORS*

	PSEUDOACUTE APPENDICITIS (%) (100 CASES)	CHRONIC APPENDICITIS (%) (100 CASES)	AUTOPSY (%) (325 CASES)
1. Obstruction definite:			
Lumen filled with feces	48	6	10.3
Lumen contains one or more fecaliths	30	10	1.4
Sharp kink of appendix†	6	2	–
Proximal cicatricial constriction of lumen	4	1	2.1
	88	19	13.8
2. Obstruction doubtful:			
Lumen contains fecal matter	2	15	31.4
3. No obstruction:			
Lumen empty or with little fecal matter on mucosa	7	66	54.8
Lumen obliterated	3	Not included‡	
	10	66	54.8
	100	100	100

*The appendices removed for appendiclausis and those removed at autopsy are not quite comparable because of the difference in the average age of the two groups. While the lumen of the appendix in the younger group (those with appendiclausis) is wider than in the older subjects and might therefore favor the entrance of fecal matter into the appendix, it would also extrude its contents back into the cecum with less difficulty than in the case of a fibrotic appendix with a narrower lumen characteristic of an older person.

†Observed in situ.

‡The incidence of obliterated appendices was 14 per cent in 325 consecutive autopsies.

Volkmann noted two other causes for a mistaken diagnosis of acute appendicitis; namely, oxyuris infestation and torsion of the appendix, which, if the blood supply is not radically interfered with, is essentially an obstruction of the lumen.

If surgery is not resorted to, the symptoms usually subside for an indefinite period, but that they are likely to recur is indicated by the fact that more than 50 per cent of the patients gave a history of previous attacks. A considerable number of patients develop acute inflammation within a week of the first evidence of appendiclausis.

Numerous patients, previously free from gastrointestinal symptoms, develop mild but persistent pain in the right lower quadrant of the abdomen with almost daily nausea and, sometimes, belching. These symptoms may persist for one month or longer, when appendectomy is finally decided upon. The appendix is found obstructed, usually with fecal matter. These cases, not being acute, fall in a group by themselves and are not included in this survey.

An explanation of the clinical syndrome resulting from the obstruction of the appendix is found in a consideration of the appendix as a part of the intestinal tract. When its communication with the cecum is interrupted, an obstruction of the bowel on a minute scale results. It differs from obstruction elsewhere in the bowel in that the main

flow of intestinal content is not disturbed, and it therefore corresponds to an experimentally produced closed loop obstruction of the bowel. Wangensteen's experiments, which formed part of his study of the etiology of acute appendicitis, substantiate this view. As part of the investigation, he exteriorized normal human appendices for the study of secretion of fluid by the appendix; the appendix was ligated at its base, with preservation of its blood supply, and its tip was opened and connected to a water manometer. Wangensteen noted that "abdominal pain and nausea, occasionally, and vomiting, less commonly, attend sustained increases of intraluminal pressure. Some of the patients exhibited slight febrile and leucocytic responses as well." The degree of obstruction is probably one of the main factors determining whether the appendix will develop fulminating infection and go on to early rupture (Wilkie's acute obstructive appendicitis) or whether it will remain free from inflammation and be only a source of annoyance to its possessor.

Rea and Kleinsasser made a follow-up study of a series of 143 patients who were operated upon for acute appendicitis but at operation showed no evidence of acute inflammation. Judging by the description of the clinical picture, these authors were dealing with cases of appendiclausis. Of the 102 patients contacted, 90 per cent had no more attacks of abdominal pain. Rea and Kleinsasser concluded that appendectomy had been wise in all these cases, despite the lack of pathologic confirmation of the involvement of the appendix.

Our own attempt at follow-up was less successful. The number of patients who responded to our inquiry is too small to warrant any conclusions, but our percentage of cures agreed with the foregoing figures.

In our series all the patients with appendiclausis had been diagnosed before operation as having acute appendicitis; mild acute appendicitis, often incorrectly designated as subacute; subsiding acute appendicitis, which pathologically is true subacute appendicitis; or an acute or a subacute flareup of chronic appendicitis. A fair proportion of these patients were taken directly to the operating room from the admitting ward; patients with subsiding acute appendicitis were usually operated upon the following morning. A large number were observed for a day or two and then operated upon because of progressing symptoms. A small number were studied for as long as a week or ten days, with x-ray examinations of the gastrointestinal and urinary organs, a diagnosis of appendicitis finally being made by a process of exclusion. A fairly large percentage of such patients showed beginning acute inflammation. These are not included in the series of patients with appendiclausis.

It is significant that the incidence of obstruction was much higher in the cases in which an erroneous diagnosis of acute appendicitis had

been made than in either of the control groups (Table I). Consequently, it would seem justifiable to assume that obstruction of the lumen is sufficient to produce the symptoms. The remaining 12 per cent free from obstruction may represent an error in diagnosis. One, of course, can do no more than speculate on the possibility that a localized spasm of the circular muscle fibers of the appendix may have created a temporary obstruction.

Why did the patients in the chronic and the post-mortem groups, in whom obstruction of the appendix occurred, presumably have no acute symptoms? No satisfactory answer can be given, but one should remember that in other diseases pathologic findings are often out of proportion to the clinical picture. There is no doubt, for example, that calculi in the gall bladder are responsible for symptoms other than colic, and yet at autopsy many patients who had been free from any digestive disturbances are found to have chronic cholecystitis and cholelithiasis.

In considering the clinical and laboratory findings on which the diagnosis of acute appendicitis is usually made, I compare the 88 cases of proved appendiclausis with 100 cases of proved simple acute appendicitis (Table II).

The analysis of the table shows that, on the whole, obstruction occurs at a slightly earlier age than acute appendicitis does, and that there is a definite reversal of the sex ratio, with the incidence of females predominating in appendiclausis.

It is interesting to note that, contrary to expectations, cramps or colic occurred only in 36 per cent of the patients with appendiclausis.

Pain was much more severe in the patients with appendicitis, which probably accounts for their earlier hospitalization.

Patients with appendiclausis were more likely to have pain localized in the right lower quadrant from the start, although, even among them, the majority had epigastric or generalized abdominal pain at the onset.

Surprisingly few patients had an interruption of the normal bowel rhythm in either group. This point is of absolutely no aid in the differential diagnosis.

Both groups of patients had gastric upsets; vomiting was somewhat more frequent and definitely more persistent in patients with appendicitis. The average temperature and pulse rate were almost identical, both being slightly elevated. (The arithmetical average in these and the following calculations was very close to the statistician's median.)

The average white blood count in cases of appendiclausis showed only a slight elevation, contrasted with a definite leucocytosis in the average case of acute appendicitis. It should be emphasized, however, that even leucopenia does not rule out acute appendicitis; conversely,

TABLE II

COMPARISON BETWEEN SIGNS AND SYMPTOMS OF ACUTE APPENDICITIS AND OF APPENDICLAUSIS

	ACUTE APPENDICITIS	APPENDICLAUSIS
Age:		
First decade	8%	5%
Second decade	33%	50%
Third decade	41%	32%
Fourth decade	13%	12%
Fifth decade on	5%	1%
Sex:		
Males	62%	31%
Females	38%	69%
Previous attacks:		
Positive history	41%	55%
Negative history	30%	30%
No data	29%	15%
Quality of pain:		
Cramps or colic	49%	36%
Steady ache or stabbing pain	25%	36%
No data	26%	28%
Average duration of present attack (prior to hospitalization)	2 days	3½ days
Onset of pain:		
Epigastric or generalized	73%	53%
Localized to the right lower quadrant from start	26%	46%
No data	1%	1%
Bowel rhythm with present attack:		
Constipation	11%	16%
Rhythm uninterrupted	55%	43%
Diarrhea	8%	13%
No data	26%	28%
Gastric upset:		
Nausea only	27%	43%
Vomiting	62%	47%
Neither	11%	9%
No data	–	1%
Average temperature	99.8° F.	99.3° F.
Average pulse	89	89
Average white blood count	15,800	11,000
Average differential P.M.N. count	82%	76%
Abdominal resistance:		
Guarding or rigidity present	84%	68%
No resistance	16%	32%
Localized abdominal tenderness present	99%	100%
Rebound tenderness:		
Present	63%	49%
Absent	25%	42%
No data	12%	9%
Rectal tenderness:		
Present	62%	59%
Absent	23%	23%
No data	15%	18%

many of the patients with appendiclausis had a leucocytosis higher than 15,000. The percentage of neutrophiles in the differential count was similar.

Abdominal resistance, localized tenderness, rebound tenderness, and rectal tenderness were all more pronounced in patients with acute ap-

pendicitis, although there were numerous persons in this group who were lacking in one or more of these findings. Localized tenderness was the most constant objective finding in both groups.

The acceptance of appendiclausis as a clinical entity justifies neither unwarranted appendectomy performed without painstaking preliminary study of the patient nor delay of operation for acute appendicitis. It does serve to explain many cases in which the pathologic examination showed no evidence of inflammation though the clinical findings indicated the necessity for operation.

SUMMARY AND CONCLUSIONS

A study of 100 cases of presumably erroneous diagnoses of acute appendicitis showed that 88 per cent of these patients had obstruction of the lumen of the appendix (without gross or microscopic evidence of active inflammatory changes). This is in contrast to an incidence of 19 per cent of obstruction in 100 cases of chronically inflamed or incidental appendices, and 14 per cent in 325 consecutive autopsies. The term appendiclausis, meaning barred appendix, is suggested for this disease.*

A comparison of the cases of appendicitis with those of appendiclausis indicates that the differential diagnosis is difficult to make. Appendiclausis is usually diagnosed at operation. Except when acute appendicitis can be excluded with more than reasonable certainty before operation, appendectomy is the treatment of choice for appendiclausis.

I wish to thank Dr. Jesse L. Carr for his assistance in providing the post-mortem material.

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*The number of autopsy appendices examined has by this time reached 400, without appreciably changing the proportion of the various conditions as indicated in the foregoing table.

A SIMPLIFIED PLASTIC OPERATION FOR HUMP, HOOK, AND TWIST OF THE NOSE

JACOB SARNOFF, M.D., BROOKLYN, N. Y.

HERE is described in brief a simplified method of dealing with the nose having a hump, a hook, and a twist.

Heretofore, as described in the various textbooks on plastic surgery, the hump is removed (Fig. 3 *A*) and the tip is shortened in the usual manner. However, in order to straighten the nose, two procedures are necessary. On the concave or narrow side, the base of the bridge of the nose, consisting of the nasal process of the superior maxilla and the nasal bone, is fractured. On the opposite or wide convex side of the nose, it is deemed necessary to remove an additional triangular segment of these bones at the base of the nose.

Fig. 1.



Fig. 2.

Fig. 1.—The entire elliptical area which is outlined indicates the amount of bone and cartilage to be removed subcutaneously for the correction of the hump. The shaded area indicates the additional amount of nasal bone to be removed from the broad, convex side. The line at the base of the nose indicates the site of the fracture on either side so as to narrow the bridge.

Fig. 2.—The masks illustrate a hump, hook, and twist of the nose in which this procedure was used, and show the result obtained.

This is done for the following reason: When the bones are fractured at the base on either side of the nose, they are manipulated so as to push the bridge of the nose from the twisted position toward the midline. When this is done, the bone on the narrow side naturally

Received for publication, September 5, 1939.

bends downward toward the wide side. In so doing the upper edge becomes depressed as compared to the nasal bone of the convex side, which becomes raised and its top border protrudes (Fig. 3 *B*). By removing this additional segment on the convex side, the nose is allowed, when straightened, to become even where the two nasal bones meet at the bridge of the nose, like a gable.

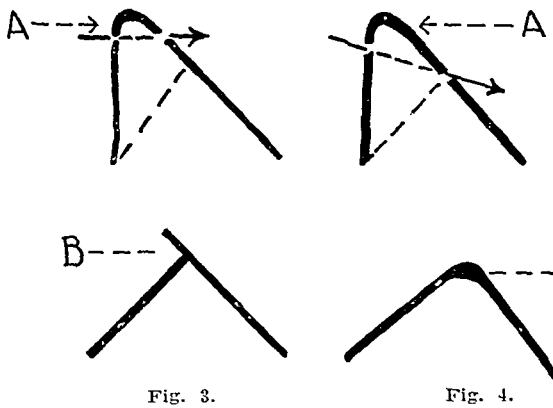


Fig. 3. Fig. 4.

Fig. 3.—Demonstrates that, when the hump is removed (*A*) and the nasal bones are fractured at their base to straighten the bridge of the nose and brought to the midline, the nasal bone on the convex or wide side protrudes above the nasal bone of the opposite side at its apex (*B*).

Fig. 4.—Demonstrates that, by removing a larger segment of the nasal bone on the convex or wide side as compared to the opposite side (*A*) and by the fracturing of the nasal bones at the base, the edges meet evenly at the apex or bridge of the nose (*B*).

I eliminate this second procedure of removing this triangular segment of bone. When removing the hump, I remove the necessary segment of the nasal bone on the concave side. On the convex side, I remove that much of the nasal bone, plus the triangular area of bone, as would have been done by the old method; but I remove it in one section at the top of the bridge instead of at the base. This can be best visualized by Figs. 1 and 4 *A*.

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Fig. 1.

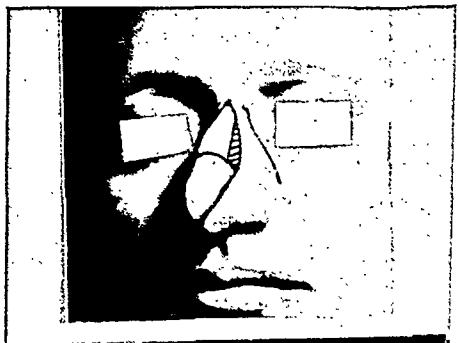


Fig. 2.

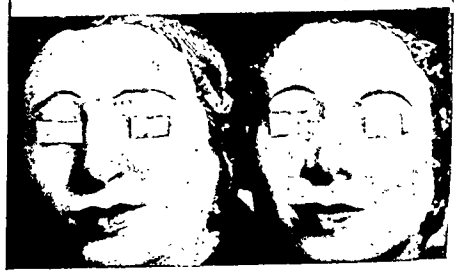


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Received for publication, September 5, 1939.

dura. Through it a fine needle is introduced, carefully penetrating the dura and entering the subarachnoid space. A needle of any desired delicacy may be used, for the resistant structures have been penetrated by the guide. We have tried long slender needles of 0.4 mm. diameter. This is the caliber of fine hypodermics. Cerebrospinal fluid will not flow back through such a needle, so it is difficult to be certain that the subarachnoid space has been entered. We have found 0.6 and 0.7 mm. needles very satisfactory.

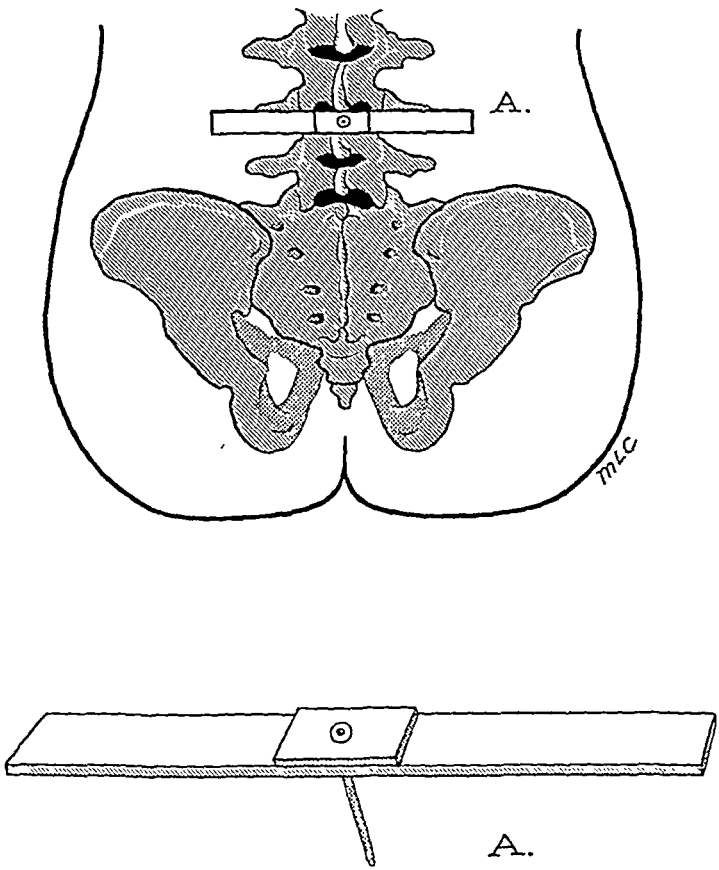


Fig. 1.—Needle guide, showing essentials of construction and manner of application.

Third, the spinal puncture is made, and the anesthetic solution is introduced before the surgeon scrubs up. At least ten minutes then passes before the operation starts. It is a serious mistake to begin an operation before anesthesia is complete. If the surgeon does not realize this, the patient does. The only special equipment which this procedure requires is a holder for the needle similar to the one illustrated (Fig. 2). Aseptic ideals are not sacrificed, but quite the reverse. The work is done with absolutely sterile instruments, instead of imperfectly sterilized hands.

SPINAL ANESTHESIA IN ARABIA

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SPINAL anesthesia is much used in the Orient. It is not a perfect method, but general anesthetics require a degree of skill often unavailable, and in addition frequently rob the operator of his only competent assistant. Moreover spinal anesthesia has real inherent merit. Its theoretical possibilities are very attractive. In the subarachnoid space the sensory nerves are assembled most conveniently. The temporary interruption of their capacity to transmit afferent impulses constitutes ideal anesthesia. In novocain we have an extremely efficient and nontoxic agent for this purpose.

But this collection of sensory nerves is protected by a bony encasement which is very complete, and the long slender aquarium in which they float contains also the medullary centers upon which life depends. Many difficulties result, and they have been only partially overcome. The anesthetic solution must be introduced into the subarachnoid space without injury to important structures. It must be brought into contact with the nerve roots which we wish to anesthetize, and, most difficult of all, its action must be limited to this desired area. Once out of control, it will quite certainly cause occasional deaths by paralyzing the medullary centers. The fundamental difficulties of spinal anesthesia are thus three, all of them problems in simple mechanics.

THE SPINAL PUNCTURE

In the midline behind are foramina through which the spinal needle can be introduced into the subarachnoid space. In the lumbar region this is easily done, and a simple spinal puncture is a fairly precise and reliable procedure. It is best considered in three steps.

First, the site of the proposed puncture is carefully anesthetized. With a fine hypodermic needle, a wheal in the skin is made, no larger perhaps than the cross section of a lead pencil. Immediately under this the subcutaneous tissues are infiltrated. This same fine needle is then inserted for one inch between the vertebral spines, and 1 or 2 c.c. of novocain solution are deposited. The spinal puncture is then entirely painless, the patient suffering no discomfort, even if the search for an opening is prolonged. This is a point of real importance for the morale of the patient depends upon it.

Second, the tough and resistant structures which overlie the dura are best penetrated by means of a substantial hollow guide which projects from the midpoint of a 6-inch bar (Fig. 1). The length of the guide itself is about 3.5 cm. The point of this guide is brought close up to the

Received for publication, November 14, 1939.

is usually satisfactory. Three and one-half cubic centimeters was found ideal for a cholecystectomy. The same dose was adequate for a splenectomy, but not quite ideal, for a little pain was felt when adhesions to the diaphragm were freed.

When the spinal puncture is made below the level of the second lumbar vertebra, no great delicacy of technique is required, for at these levels the subarachnoid space contains nothing except the cauda equina. The needle may be introduced brusquely, for the fluid-filled cavity is one-third inch deep, and, even if we drive clear across it and impinge on the vertebral body opposite, no great harm is done. Higher up the situation is very different, for the distance between the dura and the posterior surface of the cord is only 1.5 to 2 mm. This is space enough, but it requires careful work. The guide described above we have found particularly useful here, for with it in place the careful introduction of a delicate needle is not difficult, and so far as we know there have been no injuries to the cord with this technique.

The needle must be introduced carefully; also the solution must be injected slowly. The clinic routine is 1 c.c. in fifteen seconds. Introduced so, the solution sinks downward in a uniform way. The process can be readily observed in a test tube. There is little or no tendency for currents in the cerebrospinal fluid to carry such a slowly injected anesthetic toward the head.

PREVENTION OF THE SOLUTION'S SPREAD

The means available for keeping the anesthetic solution within bounds are imperfect and unsatisfactory. A solution accurately of the same specific gravity as the spinal fluid would have no tendency to move about, no matter how much the patient's position might be changed. We have no such solution. The next best thing is a solution which is heavy, for we know just where such a solution will go. With the patient in the sitting position it sinks downward and anesthetizes very thoroughly everything below the point of its introduction.

When this is impossible we introduce it with the patient lying down. It is introduced between the second and third lumbar spines, and, when the patient is turned on his back, gravity carries it into the concavity of the dorsal spine. This would seem to offer much greater opportunities for an uncontrolled diffusion of the solution upwards. In actual practice, however, we have not seen a dangerous uncontrolled diffusion of that sort. Evidently, if gross movement of the whole body of the anesthetic solution can be prevented, diffusion is not marked. The cerebrospinal fluid stretches for 14 inches in a thin sheet not more than 2 mm. thick. If isotonic solutions are used, diffusion currents are sluggish, and after twenty to thirty minutes all further diffusion is stopped by the fixation of the injected novocain in the nervous tissues. If shifting of the mass of solution is prevented, we regard the danger of diffusion upwards as very slight.

THE PLACING OF THE SOLUTION

The ideal would be, first, the introduction of the spinal needle at the point where the action of the anesthetic solution is desired, and, second, the deposition there of a solution similar in specific gravity to the spinal fluid. Unfortunately, we can do with certainty neither of these two things. In the lumbar region it is easy to introduce the spinal needle, and with care the lower two or three interspaces of the dorsal region can be penetrated in most instances; but for work in the upper abdomen we need an anesthesia which extends to the level of the fourth dorsal segment, and the introduction of the needle at such a level is very difficult. In at least 50 per cent of our cases we find it impossible, and recourse must be had to other means.

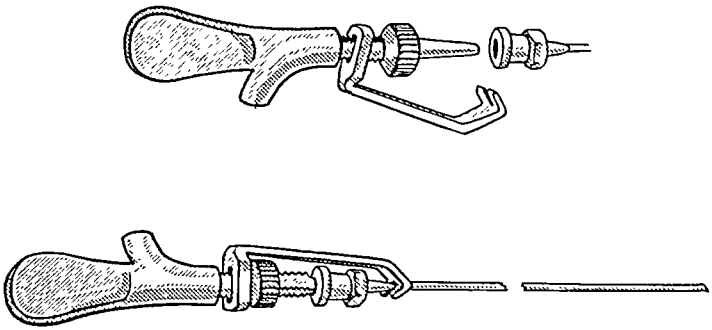


Fig. 2.—Spinal needle holder, the use of which allows aseptic puncture without the usual precautions.

A solution accurately identical with the spinal fluid in specific gravity is still further from reach, for the specific gravity of the spinal fluid varies at least between 1,004 and 1,008 in normal people. It is impossible therefore to introduce a solution of exactly the same specific gravity as the spinal fluid. The best we can do at present is to place the patient in the sitting position and introduce at the highest point of the proposed anesthesia a solution which, being heavier than the spinal fluid, will sink downward and anesthetize all the nerves below that point. This is a very precise and reliable method when it is possible to make the puncture at the desired point, but, as has been mentioned above, when high anesthesias are required for work in the upper abdomen, in about one-half of our cases we find entrance at the suitable point impossible.

In such cases the patient is laid on his side and the puncture made between the second and third lumbar spines. The introduction of the solution is easy, and, when the patient is turned on his back, the anesthetic solution gravitates into the dorsal curve of the spine and reaches the upper dorsal segments. Its extension toward the head is not under precise control, but in a general way is determined by the amount introduced and the position given to the patient. The resultant anesthesia

TABLE I*

SHOWING CAPACITY OF SUBARACHNOID SPACE, AS MEASURED FROM ITS LOWEST POINT TO LEVELS OF DIFFERENT SPINAL NERVES

	60 IN.	61 IN.	62 IN.	63 IN.	64 IN.	65 IN.	66 IN.	67 IN.	68 IN.	69 IN.	70 IN.	71 IN.	72 IN.
Th. 1	13.218	13.947	14.676	15.405	16.134	16.863	17.593	18.467	19.341	20.215	21.089	21.963	22.840
Th. 2	12.256	13.217	13.908	14.599	15.290	15.981	16.672	17.500	18.328	19.156	19.984	20.812	21.644
Th. 3	11.884	12.539	13.194	13.849	14.504	15.159	15.817	16.603	17.389	18.175	18.961	19.747	20.535
Th. 4	11.219	11.838	12.457	13.076	13.675	14.314	14.932	15.674	16.416	17.158	17.900	18.652	19.386
Th. 5	10.753	11.346	11.939	12.532	13.125	13.718	14.312	15.023	15.734	16.445	17.156	17.867	18.581
Th. 6	10.303	10.871	11.439	12.007	12.575	13.143	13.713	14.394	15.075	15.756	16.437	17.118	17.803
Th. 7	9.849	10.492	11.035	11.578	12.121	12.664	13.109	13.760	14.411	15.062	15.713	16.[illegible]	17.01[illegible]
Th. 8	9.417	9.936	10.455	10.974	11.493	12.012	12.534	13.157	13.780	14.403	15.026	15.649	16.272
Th. 9	8.725	9.206	9.687	10.168	10.649	11.130	11.612	12.189	12.766	13.343	13.920	14.497	15.076
Th. 10	7.783	8.212	8.641	9.070	9.499	9.928	10.359	10.874	11.389	11.904	12.419	12.934	13.449
Th. 11	7.299	7.701	8.103	8.505	8.907	9.309	9.714	10.197	10.680	11.163	11.646	12.129	12.612
Th. 12	6.671	7.039	7.407	7.775	8.143	8.511	8.879	9.320	9.761	10.202	10.643	11.084	11.527
L. 1	5.855	6.178	6.501	6.824	7.147	7.470	7.793	8.180	8.567	8.954	9.341	9.728	10.117
L. 2	5.094	5.375	5.656	5.937	6.218	6.499	6.780	7.117	7.454	7.791	8.128	8.465	8.802
L. 3	2.208	3.975	4.183	4.391	4.599	4.807	5.014	5.262	5.571	5.760	6.009	6.258	6.509
L. 4	3.767	2.329	2.450	2.571	2.692	2.813	2.938	3.084	3.230	3.376	3.522	3.668	3.815
L. 5	1.242	1.310	1.378	1.446	1.514	1.582	1.653	1.735	1.817	1.899	1.981	2.063	2.146
S. 1													
S. 2													
S. 3													
S. 4													
S. 5													

*The left-hand column contains the figures for a man 69 inches in height. They were obtained by freezing in dry ice the head and spinal column of an old man whose death was due to dysentery. The spine was sawed into slices 2 cm. thick, the bone and other structures surrounding the dura being carefully removed with a chisel. The resulting cylinders were scraped clean, and weighed in a chemical balance. After standing at room temperature for a number of hours, the cylinders, composed of dura and cord, were carefully reweighed, the diminution in weight giving the amount of cerebrospinal fluid previously present in each particular fragment. The method is open to various minor objections, but it should be accurate to within 5 per cent.

The figures in the other columns are obtained by simple calculation, the assumption being that all dimensions increase proportionally.

The work was done in the laboratories of Dr. Koshi, Professor of Anatomy, Madras Medical College, and our indebtedness to him it is a pleasure to acknowledge.

We have termed these the mechanical problems of spinal anesthesia. In addition there are pharmacologic problems, a number of them.

THE ANESTHETIC DRUG

Spinal anesthesia is simply a special form of conduction anesthesia. Any local anesthetic can be used, and most of them have been. Novocain, however, has largely displaced the others, for it is almost ideally nontoxic and nonirritating. When an anesthesia of an hour or an hour and a quarter is sufficient, there is little reason for looking further. When long anesthesias are required, nupercaine is probably the best drug we have.

DURATION OF THE ANESTHESIA

When brought into contact with the nerve roots in a concentration of 1 per cent, novocain affords an anesthesia lasting about one and one-fourth hours. It is to be remembered, however, that, when an anesthetic solution is injected into the subarachnoid space, it mixes with the fluid already there. Two or three cubic centimeters of a 1 per cent novocain solution injected into the subarachnoid space will anesthetize nothing. Introduced in large quantity, it is an effective anesthetic. Boehler,[1] whose work on fractures has become so famous, uses nothing else. Col. Pandali,[2] of Madras, India, has used this solution in hundreds of cases, and in quantities up to 20 c.c. Used in this way it is doubtless present about the nerve roots in practically its original strength.

As can be seen from Table I, 3 c.c. of a 5 per cent solution of novocain introduced between the tenth and eleventh dorsal segments, and gravitating downward to be mixed with the cerebrospinal fluid below that point, affords a solution of practically 1 per cent. As would be expected, the resulting anesthesia lasts about one and one-fourth hours.

When the nerve roots are bathed in a novocain solution of 2 to 3 per cent, the anesthesia will last for two and one-half hours, and sometimes longer. In Muscat we induce this longer anesthesia in patients who are to be operated upon for hemorrhoids. The clamp and cautery is the routine operation, and, by prolonging the anesthesia to two and one-half hours, much postoperative pain is avoided. Three to three and one-half cubic centimeters of a 5 per cent solution is introduced between the third and fourth, or between the fourth and fifth, lumbar spines and affords a concentration of 2 per cent around the nerve roots. The resulting anesthesia lasts for two to three hours.

We very much want a two-hour anesthesia for double hernia cases. The anesthesia should reach to the umbilicus, and for that up to 10 c.c. of a 5 per cent solution is needed. It is the common impression that such a dose of novocain is dangerously high. The impression may be mistaken. Amounts as large as this are used in local anesthesia with no bad results, and the time of absorption of the drug is about the same in the two cases. However, the introduction of such large amounts of solution

haps 10 c.c. of spinal fluid afforded almost complete relief, and there were no demonstrable aftereffects. Headaches following nupercaine anesthesia are accompanied by a rise in spinal pressure; those following a novocain anesthesia, by a fall in pressure. The introduction of 5 to 10 c.c. normal saline solution will relieve a novocain headache, as we have had occasion to demonstrate a number of times.

There are other possible causes for a headache. An acid reaction due to defective rubber tubing gave us a tremendous number of headaches on one of our medical tours. Learning from this, the anesthetic solution is set to a pH of 7.2. Weed and Wegeforth,[3] working on cats, found that the absence of calcium makes an injected fluid very irritating to the meninges, so we add to all of our anesthetic solutions calcium chloride, 0.024 per cent. The solutions are made up to be isotonic with the spinal fluid, and in cold weather they are warmed to body temperature before introduction.

Our spinal anesthetic then is fundamentally a 5 per cent solution of novocain. This is practically isotonic, the exact figure being 5.48 per cent. To the 5 per cent solution of novocain is added calcium chloride, 0.024 per cent, and the whole set to a pH of 7.2. Lately we have filtered this solution through a Seitz serum filter No. 3. Such a filtration, according to Co Tui,[4] is effective in removing from intravenous solutions the factor which causes febrile reactions. This solution is so nonirritating that we are able to use it in the out-patient department, sending the patient home immediately after the anesthesia has passed off. Occasionally, after twenty-four to forty-eight hours, a moderate headache develops, but apparently always in connection with malaria or some other additional cause.

SUMMARY

Anatomically, spinal anesthesia has almost ideal possibilities, and pharmacologically we have in novocain an extremely satisfactory agent for realizing them.

The most serious difficulties are mechanical; i.e., placing the anesthetic solution where it is wanted, and preventing its spread into dangerous territory.

The means in hand at present permit a large degree of success in using this method, and the indications for its employment are already wide.

Much further work is needed before the full possibilities of this method can be realized.

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into the subarachnoid space is of itself a somewhat shocking procedure. At the moment we are cautiously trying out 10 per cent solutions of novocain. This is not an ideal solution, as will be discussed in a following section, but it may be better than a nupercaine solution, which is the best available alternative.

For long operations in the upper abdomen, we make no effort to use novocain. Nupercaine in a solution of 1:1,600 affords an anesthesia of two hours. By using stronger solutions, this can be extended to four and even five hours.

THE STABILIZATION OF THE BLOOD PRESSURE

The vascular tone of the body is maintained by centers in the medulla and that control is mediated through the sympathetic system; i.e., that part of the autonomic system whose fibers emerge from the spinal nerves of the dorsal and lumbar regions. So far as clinical experience can be trusted, it is the splanchnic area connected with the dorsal segments which is the important factor in maintaining the blood pressure. Anesthesias which include only areas below the umbilicus affect the blood pressure very little. As a preparation for higher anesthesias, we inject ¾ gr. of ephedrine subcutaneously just before the anesthetic solution is introduced. There are cases where this proves to be inadequate, and for such patients we provide an extra assistant who injects from 1 to 3 minims of adrenalin solution every ten minutes as long as the anesthesia lasts. In these cases we have found it of great assistance to elevate the legs, the ordinary leg holders being used, and the legs raised perhaps two feet. We have seen no patients whose blood pressure could not be controlled by these means.

In our experience the drop in blood pressure has been much the same no matter what anesthetic is used. It is a function of the anesthesia, and its severity depends on the number of segments affected. During the period in which control by the vasomotor center is lacking, it is necessary to provide an adequate hormonal control, and adrenalin is the best drug we have for the purpose.

POSTANESTHETIC SEQUELAE

We have seen very little bladder paralysis in Muscat. The only postanesthetic sequelae of importance have been headaches. Apparently these are due to the mild aseptic meningitis which follows every introduction of a foreign solution into the subarachnoid space. Doubtless the less irritating the injected solution, the fewer the headaches. Novocain is the least irritating of the available anesthetics, and on that account it has come to be almost universally used. Nupercaine is more irritating. I have seen the spinal fluid show a white count of 2,000 per cu. mm., a few hours after such an anesthesia. The accompanying headache was severe, and the spinal pressure raised. The removal of per-

TABLE I

AGE INCIDENCE OF CASES WITH PROVED CARCINOMA OF THE BRONCHUS

Under 20 yr.	1
20 to 29 yr.	2
30 to 39 yr.	5
40 to 49 yr.	18
50 to 59 yr.	32
60 to 69 yr.	5
70 to 79 yr.	2

cinoma of the lung. It is of interest to note that Kimura[3] in 1923 produced lung cancer experimentally in rabbits and guinea pigs by the insufflation of tar fumes through a tracheal opening. If it can be shown that the incidence of carcinoma of the lung is actually increasing from decade to decade, it is possible that our daily contact with tar in some form, such as the dust from tar covered roads and the fumes from incomplete combustion of gasoline and oil, is a factor.

Race.—Most of our cases are from Baltimore where there is a large colored population, but the ratio in our series of cases is 5.5 whites to 1 negro.

Pathology.—Primary bronchial tumors are almost invariably epithelial in origin. The two most common varieties are the squamous cell and the adenocarcinoma. In our group of cases a great variety of diagnoses have been made from biopsy specimens, such as medullary, basal-cell, and mixed-cell carcinoma, cylindroma, angioendothelioma, thymoma, etc. Some of these bronchial tumors have such a complex cellular structure that it is impossible to classify them more specifically than that they are epithelial in origin. We find, in agreement with Clerf and Crawford,[4] that approximately 65 per cent of lung tumors are squamous-cell carcinoma. On the other hand, Samson[5] reviewed the autopsy reports on 100 cases of bronchogenic carcinoma and found 51 per cent were adenocarcinoma; 19 per cent, undifferentiated epithelial growths; and most of the other, 30 per cent, were the squamous-cell type. In addition he found 24 per cent of the squamous-cell tumors remained localized at their point of origin, usually growing by direct extension and involving only the adjacent lung or mediastinal lymph glands, and do not spread to distant parts of the body. In sharp contrast, the adenocarcinomas metastasize frequently and most commonly involve the central nervous system, adrenals, liver, and mediastinal and abdominal lymph glands. Such a clear-cut differentiation would be of immense value in planning treatment if it were possible to remove a fragment of growth through a bronchoscope and determine the type with anything like the accuracy of histologic studies at autopsy. Unfortunately, the only information we often get from a biopsy specimen is that the growth is either carcinoma, sarcoma, or is benign. More valuable diagnostic and prognostic information is obtained from the history (pains suggesting pleural involvement, symptoms arising from

BRONCHOSCOPIC EXPERIENCES WITH LUNG TUMORS*

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THE older statistics indicate that carcinoma of the bronchus constitutes 1 per cent or less of all malignant epithelial growths. With the more extensive use of the bronchoscope and biopsy has come the realization that this figure is far too low and that the true incidence of primary lung cancer, which almost always begins in a bronchus, is approximately 10.5 per cent of all carcinomas in the body.

The following report is based on the study of sixty-five bronchial tumors observed in the Bronchoscopic Clinic of the Johns Hopkins Hospital.

ETIOLOGY

Sex.—Lubarsch[1] in 1924 made a report on the incidence of carcinoma in various parts of the body, based on 86,216 autopsies. His statistics show that 8 per cent of all cancers in males and 2.5 per cent of all cancers in females arise in the bronchus. Our bronchoscopic and biopsy examinations show that carcinoma of the bronchus occurs five times more frequently in males than in females. Of 65 cases, 54, or 83 per cent, were males and 11, or 17 per cent, were females.

Age.—Like cancers elsewhere in the body, carcinoma of the bronchus is most common between the ages of 40 and 60 years, but it may occur in much younger persons. Duguid[2] in 1927 reported 107 cases, 8 of whom were less than 30 years of age. In our group of 65 cases the average age was 40 to 50 years. One patient was only 18 years of age at the time of his first symptoms. He had pain in the right side of his chest, a dull percussion note over the right lower lobe, faint breath sounds over this area, hemoptysis, and occasional chills and fever for a year preceding his admission to the hospital. Bronchoscopy showed a growth and some purulent discharge in the bronchus leading to the right lower lobe. A piece of tissue was removed for diagnosis and proved to be basal-cell carcinoma. The entire right lung was excised in November, 1936. He made an uneventful recovery, and, when last seen in August, 1938, he had no pain, cough, or evidence of lung infection, and was active as a student in one of the universities.

Table I shows the distribution by decades of our group of 65 cases.

Occupation.—Neither a review of the literature nor a study of our case records shows any proved relationship between occupation and car-

*Read before the American Bronchoscopic Society, May 26, 1939, at Rye, N. Y.
Received for publication, November 25, 1939.

in the young and the old, and finally that thoracic surgery has made such rapid strides that excision of a lobe or an entire lung now offers the best chance for recovery.

Postoperative complications are becoming less frequent. The end result depends on an early diagnosis and operation before the growth has spread to the pleura, mediastinum, or distant parts of the body.

It is interesting to note in Table III that almost every one of our patients with lung neoplasms had fever and cough, and many had pain in the chest. Without the aid of roentgen rays and bronchoscopy the recognition of lung tumor in the early and operable stage would be impossible.

TABLE III

THE MORE COMMON CLINICAL FINDINGS IN OUR GROUP OF 65 CASES

Fever	98%
Cough	95%
Pain	76%
Expectoration	75%
Hemoptysis	66%
Weight loss	65%
Dullness and diminution of breath sounds	60%
Dyspnea	55%

Bronchoscopy enables the examiner to obtain a direct view of the growth (in 75 per cent of the cases in Jackson's series) and to remove a piece of the suspected tissue for histologic examination. Even when the growth is located in a small bronchus in an upper lobe and cannot be seen through the bronchoscope, the information as to the extent of the growth and the type of organism, if there is a complicating infection, is of inestimable value to the thoracic surgeon in his preoperative and postoperative treatment. Constant practice with a trained group of assistants is essential for accurate diagnostic work with the bronchoscope. In this series of 65 cases of lung tumors, 53, or 80 per cent, were diagnosed by bronchoscopy and 92 per cent by the combination of bronchoscopy and x-ray.

Treatment.—In the lungs, as elsewhere in the body, the first requisite for successful treatment of malignant growth is an early diagnosis. In the past radiation therapy has been unsuccessful, but there is no doubt that with the perfecting of more and more penetrating rays and in conjunction with lobectomy and pneumonectomy it will ultimately play an important part in the treatment of lung cancer. In this group all cases treated with x-ray and radium alone have died (six cases).

In rare cases it is possible to excise through the bronchoscope an endobronchial growth[6] (Jackson's case is well nineteen years later) or coagulate it with a high frequency current. One of our patients treated in this way was first seen in 1930. He had increasing difficulty in breathing for a year. On account of the cough, wheezing, and abundant bronchial mucus he had been treated for asthma. Bronchoscopic

metastases, physical examination studies, contrast x-ray of the bronchi, x-rays of the lungs and bones, especially the vertebrae) than from histologic study of a biopsy specimen alone.

A squamous-cell carcinoma is more resistant to roentgen ray and radium therapy, but, due to its tendency to remain localized and to metastasize infrequently to distant parts of the body, it is more amenable to surgical excision than some other types of lung tumor.

TABLE II

HISTOLOGIC CLASSIFICATION OF OUR SERIES OF 65 BRONCHIAL TUMORS

Squamous-cell carcinoma	42
Adenocarcinoma	5
Basal-cell carcinoma	3
Oat-cell bronchogenic carcinoma	1
Medullary cell carcinoma	1
Prickle-cell carcinoma	1
Mixed-cell carcinoma	1
Undifferentiated	8
Angioendothelioma	1
Cylindroma	1
Thymoma	1

Diagnosis.—The size, location, type of growth, and presence or absence of a secondary pyogenic infection in the lung are the conditions responsible for the clinical symptoms of lung tumors. The most common symptoms are due to bronchial irritation, such as cough, expectoration, and hemoptysis; while the most common signs, atelectasis and dyspnea, are due to bronchial obstruction. The first symptoms of a new growth in the lung may be chilly sensations, slight fever, general malaise, cough and expectoration often blood tinged following a slight respiratory tract infection; or shortness of breath on exertion, wheezing, and other symptoms suggestive of asthma.

The history and physical examination are important for differentiating between lung tumor and other conditions which may simulate it, such as certain types of pneumonia, bronchiectasis or lung abscess, syphilis, fungus infection, and tuberculosis; but the most valuable diagnostic measures are fluoroscopy, roentgenograms with and without contrast filling of the bronchi and bronchoscopy, with removal of a piece of the tumor for histologic examination. If a bronchoscopic examination is unsuccessful for the definite diagnosis of a lung tumor, an artificial pneumothorax may be of the greatest aid both from an x-ray and bronchoscopic standpoint. This is also true for difficult foreign bodies. The blood and air content of the lung is greatly reduced and the entire lung collapsed in toward the main bronchi.

It is of prime importance for physicians to realize that carcinoma of the lung is not uncommon, that in the early stages it may simulate less serious maladies, that it should be thought of and excluded both

8. Bronchoscopy and x-ray studies are the greatest aids in making a diagnosis.

9. Surgical removal of the affected lobe or lung appears to offer the best therapeutic results.

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examination showed almost complete tracheal obstruction due to a growth. It was located just above the bifurcation, bled easily when touched with a cotton-tipped applicator, and a biopsy specimen proved it to be a squamous-cell, pearl-forming epithelioma. After the first coagulation treatment, which was done under local anesthesia, there was increased obstruction due to swelling and mucus, and on the following day a massive collapse of the entire left lung. The acute symptoms gradually subsided, and, although the growth has never entirely disappeared, it has been easily controlled during the past nine years by two or three coagulation treatments a year. There has never been any evidence of extension or metastasis. As soon as good breathing space was established, the patient rapidly regained the thirty pounds in weight he had lost and was able to resume his work as a carpenter. Fulguration through the bronchoscope would be of no value in the treatment of a growth that was invading the surrounding tissues or spreading to other parts of the body. Rapid progress has been made in the technique of lobectomy and pneumonectomy. Although the first successful one-stage pneumonectomy was reported by Graham and Singer[7] in 1933, it is now becoming a commonplace operation in the larger thoracic surgery clinics of this country.

In this group 20 per cent, or 13, were thought to be operable from a general diagnostic study, but in only 38 per cent of this number was the surgeon able to remove the growth successfully. All thoracic operations in this series were performed by Dr. William F. Rienhoff, Jr. In a recent paper[8] he reports 20 pneumonectomies for carcinoma with a mortality of 10 per cent.

CONCLUSIONS

1. An increasing number of reports suggest a greater relative frequency of primary carcinoma of the bronchus than has heretofore occurred.

2. The ante-mortem diagnosis of primary carcinoma of the bronchus has increased in the Johns Hopkins Hospital, simultaneously with the beginning of an active bronchoscopic clinic.

3. Primary carcinoma of the bronchus occurs most frequently between the ages of 50 and 60 years.

4. Males are affected more often than females, in a ratio of 5:1.

5. Squamous-cell carcinoma and adenocarcinoma are the two most common types of malignancy encountered in primary carcinoma of the bronchus.

6. Squamous-cell carcinoma would appear to offer the best prognosis, because of its characteristic spread by direct continuity, rather than by widespread metastases.

7. Fever, cough, expectoration, pain, and hemoptysis are the more common signs and symptoms.

8. Bronchoscopy and x-ray studies are the greatest aids in making a diagnosis.

9. Surgical removal of the affected lobe or lung appears to offer the best therapeutic results.

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Editorials

Biliary Tract Surgery and the Bad Risk Case

PREVENTION.—In a discussion of this important subject, it seems worth while at the beginning to take into consideration some of the factors dealing with the prevention of the bad risk patient with biliary tract disease. Most of these seriously ill patients could have been operated upon more safely earlier in the course of their disease. The fault usually lies in the misunderstanding of the serious consequences that may come from delay. This, to be sure, is more often the patient's attitude towards his illness than the physician's negligence. The individual confuses types of abdominal pain, indigestion, even weight loss and jaundice, with functional disorders that may clear up spontaneously. In many instances, there is delay in calling the physician and even after he is consulted, the patient may refuse to accept his advice concerning hospitalization and, particularly, concerning operation. On the other hand, it must be admitted that some patients become bad risks for surgery due to the procrastination of the physician in charge. The diagnosis is not always obvious and one can hardly criticize with too much emphasis the natural reaction on the part of the physician to save his patient an expensive hospitalization and a dangerous operative procedure. On the other hand, it is fair to say that should physicians urge their patients to submit to hospitalization, where proper study and early evaluation could be made in diseases referable to the biliary tract, bad risk cases in this group would appear less often for treatment.

The proper preoperative preparation of a patient with severe biliary tract disease may change him from a bad risk into a good one, or at least from a poor risk into a better one. When one considers the number of articles that have recently been published urging immediate operation for acute cholecystitis, we can easily imagine that this may lead to misinterpretation by a great many surgeons. I doubt it anyone really means immediate operation in all patients with acute cholecystitis, regardless of the duration of the disease and the state of dehydration. If these patients are seen within the first forty-eight hours of the onset of symptoms, they are likely to be good risks at that time and one may subject them with safety to immediate operation. On the other hand, few such patients would not be benefited by a few hours of rest and a restoration of fluid and salt balance. This is all the more true of such patients who have been ill for longer periods of time. What these authorities really mean by immediate operation is early operation, and this differentiation cannot be overemphasized.

A considerable proportion of the bad surgical risks in this group appearing for treatment in a large general clinic are patients who have been previously subjected to surgery on the biliary tract. This brings up so vividly to our minds the casualness frequently demonstrated in biliary tract surgery that it seems worth while to mention it here. Whatever operation one attempts on the biliary tract, it must be one that does not leave the patient in a worse state than he was in prior to the procedure. Thus, acutely swollen gall bladders might often be more safely drained, since edema surrounds the ducts in such a way as to make them difficult to expose and many stages of inflammation contribute markedly to increased bleeding. That these factors increase the risk cannot be denied.

In the subacute and chronic gall bladder one may do well to consider the frequency with which anomalies of the ducts and arterial supply occur. Under no circumstances, without complete visualization of the ducts, should one clamp the cystic duct prior to the removal of the gall bladder. So often one is confronted with an anomalous situation that it is not surprising that occasionally irreparable damage to the common duct or hepatic artery takes place during cholecystectomy. Except in those cases where exact visualization of the hepatic ducts, the common bile duct, the cystic duct as well as the cystic artery is possible, one should not attempt to remove the gall bladder from below upward. In patients appearing with gall stones or cholecystitis in a large general hospital, this rule would effect about one-half of the patients operated upon.. Adhesions and inflammatory reaction in the region of the ducts makes it difficult to expose them without some bleeding. Although this in itself is not serious, it does interfere with the accurate identification of structures. The operation from above downward can be greatly facilitated by producing an artificial edema by the injection of salt solution beneath the serous coat of the gall bladder. The veins, running from the gall bladder directly into the liver, can be accurately secured and tied separately. After the gall bladder has been detached as far down as the ampulla, the liver can then be retracted and the remaining portion of the dissection carried out under direct vision so that the cystic artery and the cystic duct can be completely separated from the surrounding structures and secured without any danger of tenting the common duct or injuring the hepatic artery. This method of procedure has another distinct advantage in that it allows a more accurate preservation of a cuff of the serous coat which can be sutured over the raw surface of the liver at the close of the operation. So often in removal of the gall bladder from below up, the attempt to save an adequate portion of the serous coat is unsuccessful, since this structure has a tendency to peel completely away from its liver attachment. By careful peritonealization of the gall bladder bed, one may prevent a future serious risk case since adhesions between the duodenum and the liver may complicate any procedure that has to be carried out in this region at a later time.

Plan of Procedure.—When the bad risk case appears for treatment, one then is confronted with the problem of what can be done to restore him to normal health. The history of the patient should include the type of onset of illness, whether it was sudden or gradual, and the degree and character of pain, if any. One also wishes to learn about previous episodes of discomfort or pain in this region, indigestion, flatulence, etc. Of less importance is the question of previous infectious disease, such as typhoid fever or influenza. One should try to get the operative note of any previous operation, since it is helpful to learn whether or not the gall bladder was removed and if the common duct was explored.

A proper evaluation of the risk is next in order. The age and general condition of the patient, complicating disorders, and the present nutritional state are of utmost importance. It is a dangerous rule to set aside certain individuals as hopeless from the standpoint of relief as is frequently done. One must remember that painless jaundice may be due to a stone in the common duct and that long respites from obstruction of the duct by carcinoma of the head of the pancreas can be obtained by a re-establishment of continuity between the gall bladder and the intestinal tract.

General measures of preparation for surgery in the poor risk case are well understood. People who cannot partake of food by mouth may have their appetites improved by the correction of some of their chemical faults. Often in jaundiced patients this may be brought about by feeding another patient's bile or to a less degree by dissected animal bile or bile salts. In some extreme cases it is worth while to consider doing a jejunostomy for feeding as a preliminary step; this makes it possible to improve the risk very materially for a major procedure in the region of the liver and pancreas. The water-soluble vitamins are of great importance in helping to restore these patients to a state of nutrition compatible with major surgery.

Certain special preparations are frequently in order; the most striking of these is vitamin K and cholic acid in the deeply jaundiced patient. This may be carried out by a variety of measures; it can be done by food if the patient can eat; it may be done by giving vitamin K and bile salts by mouth or by jejunostomy. Recently, the synthetic vitamin K in the form of the naphthoquinone derivatives[1] has been made available. This substance works very quickly in comparison to the extracts previously used, so that now the prothrombin level can be elevated to a normal phase within a period of from one to three days. This will shortly become standardized to a point where accurate laboratory determinations of the prothrombin level will not always be necessary. Even now, one would be justified under certain circumstances in giving large doses of vitamin K and cholic acid or its chemical substitute to a jaundiced patient for a definite period of time prior to operation without

accurate laboratory control. One must not overlook the fact that the prothrombin level drops immediately after operation so that there should be a high level prior to operation, and the vitamin K and cholic acid should be continued immediately after operation. In very sick patients not likely to be able to take mouth feedings soon after operation, a jejunostomy for feeding should be supplemented.

Logical Surgical Approaches.—In dealing with the bad risk case, one must keep in mind the importance of having the surgical procedure outlined in accord with the patient's condition and his ability to withstand surgery. The commonest and perhaps most important factor has already been mentioned, the proper management of the acute cholecystitis with or without gangrene. Although our figures at the Massachusetts General Hospital would indicate that the mortality in simple drainage of the gall bladder was three times as high as in cholecystectomy,[2] it does not give a true value to the procedure. In our cases drainage was done only on those patients who were extremely old and feeble or in very late stages of their disease. Some of them were moribund at the time of operation, and others had already perforated, causing a localized abscess formation or some generalized infection to the peritoneal cavity. In spite of this statistical figure, one cannot help but feel that in many cases of acute cholecystitis simple drainage of the gall bladder may be a life-saving procedure. Under these circumstances, one need make no apology for this attitude, accepting without any hesitation the probability of a future cholecystectomy.

In the bad risk patient with jaundice one should be careful not to remove the gall bladder as the first step of the procedure. One should make sure that he is dealing with a remediable condition, such as stone in the common duct, before he does a cholecystectomy. If the gall bladder is markedly distended and if it contains bile with pigment in it and if there is thickening in the region of the head of the pancreas, it is far wiser not to remove the gall bladder until the cause of the obstruction is definitely ascertained. This frequently necessitates emptying the gall bladder with a suction trocar as a preliminary procedure in order to allow proper exposure and exploration of the ducts. At times, one may use from within the duct a small sharp curette such as used for an endometrial biopsy to obtain from the region of the papilla of Vater a fragment of tissue which the pathologist can examine immediately and establish definitely the presence of malignant disease. Having determined that one is dealing with the type of obstruction that cannot be immediately relieved, continuity between the gall bladder and the gastrointestinal tract can be done, thus giving the patient a respite from his obstructive jaundice. One may feel that the lesion is favorable for resection and plan a multiple stage resection of the entire area as described by Whipple, Parsons, and Mullins.[3]

Repair of injured ducts has been thoroughly discussed by Walters,[4] Lahey,[5] and others and cannot be taken up in any detail here. If one can be fortunate enough to have a patient referred early after injury to the common bile duct, one may well be able to re-establish continuity by an accurate end-to-end suture; this, after all, is the simplest and best method of procedure. One cannot do plastics on the duct with any assurance that constriction will not result in the future; however, when possible, it should always be tried, since it re-establishes continuity in a more normal fashion. One wishes to avoid, if possible, anastomosis between the duct and the gastrointestinal tract, since under these circumstances an ascending cholangeitis is so apt to occur. This has been forcibly brought out by Eliason and Johnson[6] and others. However, if the injury has been of long duration, one will usually find the distal segment of the duct a fibrous cord with so little lumen that a plastic repair between the proximal and distal ends is impossible or at best unsatisfactory. Wilson[7] has recently devised an ingenious method of anastomosing the proximal segment of the common duct to a tunnel in the anterior wall of the stomach. This is so fashioned that reflux material from the gastrointestinal tract into the biliary tree is unlikely and this will probably become a popular procedure. Whipple[8] has recently advocated the use of the free end of the divided jejunum for anastomosis to the gall bladder. This is done in such a fashion that the peristaltic waves in this segment of jejunum is in the direction of the intestinal tract. The proximal segment of jejunum is implanted into the lateral surface of the bowel at a lower level after the method of Roux. Such an anastomosis can be accomplished between the jejunum and the proximal end of the common bile duct and, if a tube is used over which to make the anastomosis, the suture can be accurately accomplished. In one instance, at least satisfactory function was established by this procedure and we believe it offers one of the better methods of re-establishing continuity between the duct and the gastrointestinal tract. The older methods of anastomosis between the end of the duct and the side of the duodenum (lateral anastomoses between these structures, etc.), I believe, will continue to result in a very high percentage of cholangeitis and for this reason should be utilized only when one of the more logical procedures cannot be carried out. One should mention the implantation of biliary fistulas into the gastrointestinal tract. The first case reported by Williams and Smithwick[9] was successful, since it was in a young boy with a congenital obstruction to his common duct. Most of these procedures, however, have been carried out on adults who have had destroyed common ducts, and many of them have failed due to a gradual fibrosis of the sinus tract.

In conclusion, I wish to stress the importance of careful surgery on the biliary tract at the primary operation, thus preventing a certain number of bad risk cases. Also, I wish to urge early exploration in pa-

tients with questionable lesions. Operation is too often looked upon as a last resort. The bad risk case having appeared, he must be carefully studied, carefully evaluated, carefully prepared for operation; and when he is subjected to surgery, it must be borne in mind that the procedure chosen must be in accordance with the patient's ability to withstand it.

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On the Misuse of "Meticulous"

"... if thou be meticulous, thou dare not see blood drawn. . ."

—Old Scotch Chronicle.

TO THE medical cliché expert, no scientific paper or discussion is properly written unless it has described the "meticulous technique" or has emphasized the "need for meticulousness." He seems unacquainted with the fact that "meticulous" is derived from "metus" meaning fearful or timid and that "meticulous" according to Webster implies needless caution, finical hair-splitting, and old-maidish hypercritical senseless devotion to details. With absolute disregard for true meaning, he uses "meticulous" to infer accurate thoroughness or studious precision. The Autocrat of the Breakfast Table called this "verbicide" or "the violent treatment of a word with fatal results to its legitimate meaning." And "the question is," said Alice, "whether you *can* make words mean so many different things."

Mencken in *The American Language* classifies "meticulous" as a vogue-word or counter-word; that is to say, a novelty which is worked so hard and in so many situations that it loses all definite meaning. The offending medical authors not only copy opinions of all sorts from each other, but they reproduce words and phrases and transplant them into their current articles. Worst of all, they imitate grammatical

blunders and give them new life by repetitious misapplication. This prevalent vogue for "meticulous" is a good illustration and reminds one of Tennyson's

"Wild words wander here and there;
God's great gift of speech abused."

It would be instructive (though too tedious) to seek the earliest improper use of "meticulous" in some journal where a careless medical author introduced this high-sounding, mouth-filling adjective to a meaning it had never borne before. If he had thought instead of "circumspect," which carries the meaning he intended, and had followed Sir Thomas Browne's advice to "*move circumspectly, not meticulously*," how much more scientifically accurate his phrase would have been.

So much attention is here devoted to one word because it is a most characteristic fault of modern medical literature. Almost every book, monograph, or lecture repeats this error until it seems that all doctors must consider themselves timid old maids afraid of the sight of blood or fearful of every procedure they perform. Perhaps if they understood the proper meaning and application of "meticulous" they would discontinue its use altogether or at least restore it to its original lexicographic status.

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Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

SOME CURRENT PROBLEMS OF ANESTHESIA

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THE material covered here is based chiefly on that catalogued in *Index Medicus* in the three-year period from the middle of 1936 to the middle of 1939. While work appearing prior to the first date has often been referred to, no attempt has been made to include material catalogued after June, 1939.

Most of the work included in this review has, if not direct clinical interest, at least fairly close clinical implications. Occasionally, however, new and stimulating fields which do not fit either of these categories are referred to in some detail, for background.

GENERAL ANESTHESIA AND THE NERVOUS SYSTEM

Probably the greatest single problem of anesthesia concerns the changes produced in the nervous system by anesthetic agents. Until these effects are better understood, the administration of anesthesia and the evaluation of anesthetic agents must continue, to a great extent, on an empirical basis. The importance of this problem justifies some consideration of it here. Much work of a fundamental character which might logically be included here, but which cannot be, because of space limitations, is described in a review by Seevers (1939).

Anesthetic Potency.—

Potency and Constitution of Agent: The problem of anesthetic potency and its relation to the presence of single and double bonds between carbon atoms has been considered by Burger (1937) in relation to the Baeyer-Thiele theory of partial valencies. The highly speculative nature of this paper excludes a detailed consideration of its content here. Burger has raised again an old question: Have we any right to assume that the thing we call narcosis or anesthesia has a single mechanism of production? It is possible that anesthesia refers to a variety of different kind of events which have one feature in common, the reversible paralysis of the nervous system. Even a cursory appraisal of the literature on the subject makes it apparent that the process one observer is studying based upon his criterion of narcosis may not be at all the same process another man studies based upon a different criterion. On the basis of the rather meager evidence available, it is not possible to state dogmatically that a general theory of anesthesia must be found that will

include the action of all agents which produce reversible paralysis of the central nervous system. The desired end effect may be produced by a number of fundamentally different processes. One must be at least somewhat guarded in listing as "incompatible" various "theories" of anesthesia.

In a further effort to correlate chemical constitution of anesthetic agents with the electrical phenomena of the cerebral cortex, Beecher (1939, 1940) has studied the anesthesia produced by a homologous series of seven aliphatic alcohols, starting with methyl. The same levels of anesthesia have been used for comparisons. A correlation between the number of carbon atoms present in each of the alcohols and the frequency of the cortical electrical waves has been demonstrated; the frequency is slowed with an increase in the number of carbon atoms; that is, presumably, with increase in anesthetic potency of the anesthetic agent. Evidence confirmatory of this has been found in a comparison of the cortical effects of primary and tertiary forms of the alcohols; anesthetic potency parallels, and appears to be related to slowing of the frequency of the cortical potentials.

When Hjort, deBeer, Buck, and Ide (1935) compared a homologous series of ureas, they found that their hypnotic potencies increase approximately twofold for each addition of a CH_2 group in the aliphatic portion; that in general $\frac{\text{heptane}}{\text{water}}$ distribution coefficients parallel hypnotic potency and toxicity; and that the more potent unsymmetrical alkylaryl ureas are more effective in lowering surface tension. In this connection it can be said that the steepness of the curve, or the rate of change of surface tension with the natural logarithm of the concentration, is proportional to the excess of solute adsorbed at the surface. In conjunction with this, it is interesting to cite the work of King, Hall, Andrews, and Cole (1930), who find that narcotic activity (measured by liminal concentration) parallels the adsorption value at a paraffin-water interface. Hiller (1927) has shown that narcotics, while producing anesthesia when acting on the surface of amoebae, do not when injected into them.

In simple ureas, physical rather than chemical properties influence hypnotic action.

As a result of their study of a large series of ureas, Buck, Hjort, and deBeer (1935) state that in the alkyl ureas molecular weight is a determining factor in hypnotic effectiveness, as with the aliphatic alcohols.

In a study of a large series of thioureas, deBeer, Buck, Ide, and Hjort (1936) found that the hypnotic effects improve with increase in molecular weight in homologous series. They found that the maximum effect occurs when alkyl substituents reach the propyl to amyl groups.

Buck, Hjort, deBeer, Ferry, and Ide (1937) have studied a large series of unsymmetrical alkylaryl ureas. They have attempted to relate the physiologic activities of sixty-four of the compounds to certain of their physical properties. Their results permit a number of generalizations. In homologous series the minimum hypnotic dose and the minimum lethal dose values vary inversely with melting points and water solubilities and directly with molecular weights, $\frac{\text{heptane}}{\text{water}}$ distribution coefficients, and the powers for lowering the surface tension of water. They find the isoalkyl ureas are physiologically less active than the normal alkyl isomers.

While hypnosis is a common characteristic of the ureas, the loss of this quality occurs when hydroxyl and carboxyl groups are incorporated. This is not surprising since introduction of these groups usually decreases potency regardless of the action of the parent substance (Hjort, deBeer, Buck, Ide, and Fassett [1937]).

Halogenation potentiates anesthetic potency in these compounds as elsewhere.

Seasonal Influences: DeBeer, Hjort, and Cook (1939) have conducted an analysis of seasonal influences upon the response of albino mice to anesthetics. Unsymmetrical n-propyl-o-tolyl urea and the sodium salt of ethyl-n-hexylbarbituric acid were chosen as representatives of two chemically different classes of hypnotics. No significant seasonal variations in the toxicity of either of these agents were found. It is emphasized that there is no proof that generalizations concerning one effect of a drug, for example, toxicity, necessarily apply to another, such as hypnosis.

In the hypnotic range both compounds during the month of January differed significantly from those of the other seasonal periods. They were both less potent during January.

No diurnal variations in hypnotic potency were found; no relationships between hynotic potency and either barometric pressure or environmental temperature were established.

In a further study of seasonal influences on the duration of anesthesia in albino mice, they find that different doses of n-propyl-o-tolyl urea and sodium ethyl-n-hexylbarbiturate (as two anesthetic agents representing diverse chemical classes) gave results showing variations at different times of year that were significantly greater than would be expected from chance alone.

Sex: Nicholas and Barron (1932) report a sex difference in response to anesthesia, the females (almost all were pregnant) having a much smaller tolerance (50 per cent) than the males for sodium amytal.

Holek and Kanân (1935) report confirmation of the observation of Nicholas and Barron that the female white rat is much more sensitive to amytal than the male (longer sleeping time; more apt to die). Con-

trary to Nicholas and Barron, they find a similar sex difference with nembutal, and, contrary to Kennedy, they find a similar sex difference with evipan and evipal. They report that summer males are much more sensitive than winter males to evipan. They were unable to detect sex differences to evipan in the dog, cat, rabbit, guinea pig, white mouse, turtle, or frog. Unlike the results with nembutal and evipal, they could find no sex difference in the white rat to barbital or phenobarbital.

Störtebecker (1939) refers to a previous paper wherein he stated that the estrogenic hormones and estrone and testis hormone augment the resistance of the organism to anesthetics like ether and alcohol.

Cameron (1939) reports the following interesting results of castration (1-year-old rats, castration eleven months previously) shown in Table I.

TABLE I

NUMBER OF RATS	FOLLOWING 40 MG. NEMBUTAL PER KG. SUBCUTANEOUSLY. MEAN DURATION OF SLEEP IN MINUTES	PERCENTAGE OF MORTALITY
18 castrated females	223 ± 12	22
30 normal females	100 ± 4	0

In discussing this paper Brennan comments that he has given evipan to over 1,000 patients who were receiving radium for carcinoma of the cervix, nearly all of whom had received a previous sterilizing dose of x-ray radiation. They required a longer recovery period than normal.

Miscellaneous: Seevers, Bennett, Pohle, and Reinardy (1937) have studied the analgesia produced by nitrous oxide, ethylene, and cyclopropane in the normal human subject. By determining the concentration of the different gases, which on continuous inhalation produce an equal elevation of the pain threshold to a level arbitrarily established, an estimation can be made of the relative analgesic potencies of the gases. Cyclopropane is approximately eight times as potent as nitrous oxide and six times as potent as ethylene.

Lehmann and Knoefel (1938) find that the anesthetic potency of tribromethanol and trichlorethanol is essentially equal, both being more potent than chloral hydrate, compared by weight. Tribromethanol is more active in depressing respiratory rate than are trichlorethanol and chloral hydrate. Tribromethanol and trichlorethanol have about the same circulatory depressing action. Both are more depressant in this regard than chloral hydrate. These studies are based upon observations in albino rats, rabbits, and dogs.

Some Points Concerning the Mechanism of the Anesthesia Process.—The threshold electrical stimulus is a convenient expression for the excitability of tissue. The intensity and duration of an electrical stimulus are both of importance. Realizing this, Lapicque set about

devising a single expression to cover the relationship. He took that intensity of stimulus which is just effective when acting for infinite time, called the rheobase, and doubled it. He then found the time necessary for this doubled stimulus to be just effective in a given case. He called this time the "chronaxie" and suggested that it be used as a measure of tissue excitability.

A number of attempts have been made to use the determination of the chronaxie in studies on the effects of anesthetics on nerve. Anesthetics depress excitability, judging by intensity and duration of threshold electrical stimulus. The chronaxie which purports to represent these factors fails to do so in anesthesia (Knoefel [1935]). It does not vary directly with excitability and cannot be used satisfactorily in studies of narcosis. Knoefel has found it impossible to relate its quantitative changes, for example, to concentration of drug. In studies of cocaine hydrochloride, chloral hydrate, and urethane on a frog nerve-muscle preparation, he found that the chronaxie bears a false relationship to the true excitability as judged by intensity-duration curves and is not an index of the excitability of nerve during anesthesia.

The great development of electrophysiology in recent years has provided new tools for attack on the problem of the nature of the anesthesia process. Only a few papers in this connection can be considered here. In addition to these (dealing with the electroencephalogram), the following workers may be referred to: Berger (1929, 1930), Bremer and Moldaver (1934), Bremer (1937), Derbyshire, Rempel, Forbes, and Lambert (1936), Fischer (1932), Forbes and Morison (1939), Gerard, Marshall, and Saul (1936), Gibbs, Davis, and Lennox (1935), Jasper and Andrews (1936), Kornmüller (1935), many papers of Adrian, Bremer, the Davises, and others.

In an effort to get a better understanding of the events transpiring in the cerebral cortex during anesthesia, Beecher, McDonough, and Forbes (1938) have considered the effects in cats of blood pressure changes, produced abruptly by cardiac tamponade, on cortical potentials during anesthesia. At a constant level of anesthesia a fall in blood pressure is followed by cortical electrical changes which are indistinguishable from those caused by an increase in the depth of anesthesia. The clinical implication of this is obvious. Data are presented in this paper which suggest that a barbiturate blocks ordinary streams of afferent impulses, but perhaps simply raises thresholds in channels of approach to the cortex and thus "puts the cortex to sleep"; while massive sensory stimuli (strong shock to sciatic nerve), by virtue of a number of simultaneous nerve impulses, break through the partial block and initiate the cortifugal discharge, or perhaps laterally spreading discharge, which accounts for the "secondary discharge" which can be elicited under the deep anesthesia produced by certain agents, notably the nonvolatile ones, as the barbiturates. The fact that this secondary

discharge is not evoked when the cortex is already active, as for example in light barbiturate anesthesia, and its immediate subsidence on rapidly repeated volleys indicates a "line busy" effect. When the mechanism is thrown into action, it becomes refractory to further stimuli for nearly a second.

In a subsequent paper (1939) these observers report the striking similarity of the effects of low spinal transection to the effects produced by a group of nonvolatile anesthetic agents on the character of the flexion response when the central end of the cut sciatic nerve is stimulated. Isotonic and isometric muscle studies with muscle action currents have been used to demonstrate that under ether anesthesia a relatively sustained, cumulative reflex contraction of the leg flexors is regularly found upon repeated central stimulation of the sciatic nerve or its popliteal division; whereas, under barbiturate anesthesia (evipal) larger, isolated noncumulative twitches of the muscle occur in response to stimulation. The difference appears to be a matter of afterdischarge, great in the case of ether, but little under barbiturate anesthesia. From this it is inferred that the "long-circuiting" of sensory impulses is much more seriously curtailed under barbiturate anesthesia than under ether. The behavior of the flexion reflex of the leg under fifteen other anesthetic agents is reported.

In another study Beecher and McDonough (1939), on examining the response of the cortical potentials in cats to anesthesia with seventeen agents, find that, when these agents were considered with reference to molecular size, volatility, frequency of cortical waves, voltage and pattern of waves, response of voltage to sciatic stimulation, the presence or absence of a secondary discharge, and the character of the flexion reflex, the agents surprisingly fell quite sharply into two distinct groups, suggesting a similarity of central nervous effect notwithstanding wide differences in chemical structure and other organic effects.

Drohocki and Drohocka (1939) registered simultaneously the electrical activity in the brain at two levels: cerebral cortex (area striata) and the thalamus. They conclude that the action of various anesthetics cannot be expressed as brain-stem or cortex-acting agents. This presents further evidence, if any is needed, against Pick's concept of "brain-stem anesthetics," etc.

The influence of anesthetics and hypnotics upon polarizability in the cat's brain was studied by Spiegel and Spiegel-Adolf (1938) as a measure of cellular permeability. Ether, chloroform, chloral hydrate, and barbiturates increased the "polarization index." This effect was interpreted as indicating an increase in density of the cellular surface films.

Quastel and his co-workers have provided data of interest in connection with an old general theory of anesthesia which suggests that an interference in brain oxidations may be involved in narcosis. The

mechanism of glucose catabolism in the brain is far from certain at this time. It is not known, for example, whether lactic acid is a direct intermediate or whether it arises from pyruvic acid as a side reaction. Leaving the controversial problems aside, Stone (1938) set about determining the effects of anesthetics and of convulsant drugs upon the brain lactic acid content of mice. His technique included practically instantaneous freezing in liquid air to prevent post-mortem accumulation of lactic acid. He found a significant lowering of the lactic acid content of the brain under phenobarbital, amytal, and ether anesthesia. The low brain lactic acid values found here are in agreement with the view that cerebral metabolism is depressed during anesthesia. The brain lactic acid is also significantly decreased during insulin convulsions. However, during picrotoxin convulsions which have lasted for from two to ten minutes, the brain lactic acid is increased above normal, although no increase appears at the beginning of the convulsion. The varying effects of other convulsants are described.

Nassonov and Alexandrov (1938) consider that the theory of Warburg perhaps best explains anesthesia. They have studied the capacity of the toxic substances, anesthetics included, to inhibit the adsorption of colored substances. They report that the results obtained show that the blockage of adsorption effected by anesthetics is the immediate cause of an alteration in the state of the molecules of the living substance; this alteration occasions an inhibition of living functions and leads to death.

Ebbecke (1936) draws a parallel between mechanical anesthesia and chemical anesthesia. Chemical anesthetics, as well as physical compression, cause reversible paralyses and irreversible injuries to the various life phenomena of animals and plants. Living beings or the organs of a living being arrange themselves in a similar series, according to sensitiveness or resistance to both types of agents. Both types cause excitation phenomena in subanesthetic doses, contraction and shortening of muscles in greater than anesthetic doses, and are comparable in their action even in details. As a common explanation for the similar effects of both types of agents, Ebbecke suggests that the increase in viscosity at the cell boundaries and cell surfaces may be important. It is possible that this increased viscosity makes diffusion and exchange of substances difficult (surface condensation, decrease of permeability).

Central Nervous System Recovery Sequences From General Anesthesia.—

In a previous article Cornsweet has reported his observations of the recovery sequence after anesthetization with ether. He states that the animals exhibited progressive cephalocaudad recovery tendencies similar to the developmental sequence of locomotion, for example, in post-

discharge is not evoked when the cortex is already active, as for example in light barbiturate anesthesia, and its immediate subsidence on rapidly repeated volleys indicates a "line busy" effect. When the mechanism is thrown into action, it becomes refractory to further stimuli for nearly a second.

In a subsequent paper (1939) these observers report the striking similarity of the effects of low spinal transection to the effects produced by a group of nonvolatile anesthetic agents on the character of the flexion response when the central end of the cut sciatic nerve is stimulated. Isotonic and isometric muscle studies with muscle action currents have been used to demonstrate that under ether anesthesia a relatively sustained, cumulative reflex contraction of the leg flexors is regularly found upon repeated central stimulation of the sciatic nerve or its popliteal division; whereas, under barbiturate anesthesia (evipal) larger, isolated noncumulative twitches of the muscle occur in response to stimulation. The difference appears to be a matter of afterdischarge, great in the case of ether, but little under barbiturate anesthesia. From this it is inferred that the "long-circuiting" of sensory impulses is much more seriously curtailed under barbiturate anesthesia than under ether. The behavior of the flexion reflex of the leg under fifteen other anesthetic agents is reported.

In another study Beecher and McDonough (1939), on examining the response of the cortical potentials in cats to anesthesia with seventeen agents, find that, when these agents were considered with reference to molecular size, volatility, frequency of cortical waves, voltage and pattern of waves, response of voltage to sciatic stimulation, the presence or absence of a secondary discharge, and the character of the flexion reflex, the agents surprisingly fell quite sharply into two distinct groups, suggesting a similarity of central nervous effect notwithstanding wide differences in chemical structure and other organic effects.

Drohocki and Drohocka (1939) registered simultaneously the electrical activity in the brain at two levels: cerebral cortex (area striata) and the thalamus. They conclude that the action of various anesthetics cannot be expressed as brain-stem or cortex-acting agents. This presents further evidence, if any is needed, against Pick's concept of "brain-stem anesthetics," etc.

The influence of anesthetics and hypnotics upon polarizability in the cat's brain was studied by Spiegel and Spiegel-Adolf (1938) as a measure of cellular permeability. Ether, chloroform, chloral hydrate, and barbiturates increased the "polarization index." This effect was interpreted as indicating an increase in density of the cellular surface films.

Quastel and his co-workers have provided data of interest in connection with an old general theory of anesthesia which suggests that an interference in brain oxidations may be involved in narcosis. The

Effect of a Barbiturate on Neurogenic Hyperpyrexia.—

Ranson and Clark (1938) recall that lesions of the anterior hypothalamus are frequently associated with hyperthermia. When these lesions were experimentally produced and the operation was carried out under nembutal anesthesia, the hyperthermia did not appear until the depressing effect of the nembutal had worn off, after the lapse of several hours. It is suggested that nembutal might be useful in combatting the hyperthermia observed following some intracranial operations.

Tolerance to Barbiturates.—

Ettinger (1938) used dial to produce surgical anesthesia repeatedly in seven dogs; three of these developed a tolerance such that the dose which first produced anesthesia for eight hours later lasted for one hour or less. It was shown that, when nembutal was used to produce anesthesia (in five dogs), the duration of the second anesthesia might drop as low as one-half the initial duration; but after this as many as fifty-three injections over a period of eighty-three days effected approximately the same duration of anesthesia.

Donald and Raventós (1939) show what they believe to be a greater susceptibility of young pigs to sodium evipan than that of older pigs.

Anesthesia and Conditioned Responses.—

Pavlov and his associates were the first to observe that conditioned salivary reflexes could be modified by alcohol, caffeine, chloral hydrate, bromide, etc. Recently Dworkin, Bourne, and Raginsky (1937) have studied in dogs and cats the changes in conditioned alimentary motor responses brought about by alcohol, amytal, nembutal, avertin, and paraldehyde. These were effective in weakening the processes of inhibition. Bulbocapnine, carbon dioxide, nitrous oxide, and ethylene were uniformly depressant. Morphine and hyoscine abolished the positive responses apparently by producing nausea and loss of interest in the food.

In another study (1937) these investigators were concerned with the action of several sedative drugs upon a conditioning neurosis of the dog. Neuroses are produced by making conflicting signals indistinguishable to the dog. The appearance of a nervous collapse is produced. Amytal, nembutal, alcohol, and avertin abolish most of the signs of inhibitory neurosis in dogs. After twenty-four hours, however, profound inhibition supervenes. Sodium bromide administered daily for ten successive days produces full recovery. This may be maintained for weeks or months after its administration has been interrupted.

As a curiosity, the following note might be appended to this section. Ströder (1938) reports that hypnotized frogs could be carried to a given level of anesthesia (urethane) much quicker than nonhypnotized ones.

natal behavior. (During induction the reverse sequence was observed.) In the present article (1938) he has repeated the observations using cyclopropane and nitrous oxide as the anesthetic agents in white rats. (Not enough data are given to be certain asphyxia was ruled out as a factor.)

While the same behavior sequence during induction, and the reverse during recovery, was observed under ether, cyclopropane, or nitrous oxide, cyclopropane produced a slower change than nitrous oxide. In this latter case recovery was rapid, with certain intermediary steps being skipped. The effect with nitrous oxide was that of a telescoping of responses. The 1-month-old animals are said to follow the same sequential patterning as the older ones.

Cornsweet's statement is open to some question when he says that the fact that these animals went under anesthesia in a caudocephalad direction (further proof needed) is unlike that observed in man when the order of anesthetization is in the order of "cerebrum, spinal cord, and, lastly, medulla."

Deshaies (1938) has studied the awakening from anesthesia in 40 women and 25 men (ether, 32 cases; Schleich's mixture, 22; chloroform, 5; nitrous oxide, 5; ethyl chloride, 1). Analytically considered, the awakening of psychic functions has three aspects: motor, affective, and intellectual. He attempts to follow the events in the nervous system by observation, for example, of muscular expression. Under this he considers general, facial, and vocal expression. The will is considered, as are attention, memory, perception, dreams, and so on.

Effect of Body Temperature on the Establishment of a State of Anesthesia.—

Tiffeneau and Barclay (1937) report that in guinea pigs in a state of hypothermia anesthesia with propyl bromide is established in less time than in normal animals; and, further, that the tension of propyl bromide in different regions of the brain is less than "normal." They suggest that in hypothermia there is a decrease in the reflex action of the cerebral centers.

Tiffeneau and Broun (1937) review the work of Meyer and others on the effect of increasing temperature in increasing anesthetic potency. They find, in studying a fish, that propyl bromide anesthesia (determined by a loss of reflex activity) occurs about twice as quickly at +25° as at +15°. The anesthetic fixed in the brain is twice as great at 25° as it is at 15° (per unit of tissue and time). This is further discussed in subsequent papers by Tiffeneau and Cahen (1938). Here the effect of body temperature on anesthesia has been studied. In the following section the reverse problem has been investigated.

Butanes and Pentanes: Stoughton and Lamson (1936) have made a study of the anesthetic activity of the butanes and the pentanes. Pentane was found to be more active, as well as more toxic, than butane. This agrees with the findings of Führer and Lazarew and fits in, of course, with the law of Richardson. Branched isomers of butane and pentane showed less activity, as well as less lethality, than the straight-chain forms.

A Cyclic Ether: Tetrahydrofurane, a cyclic ether, structurally related to both diethyl ether and cyclopropane, was prepared and tested by Stoughton and Robbins (1936) on mice and on dogs. Many toxic manifestations were produced; anesthesia was characterized by prolonged induction and recovery, poor relaxation, a marked fall in blood pressure, respiratory stimulation, and a small safety margin.

Henderson and Smith (1936) have studied the anesthetic effects of some furan derivatives and conclude that these agents are "not of clinical value."

Divinyl Ether, Vinethene: The Council on Pharmacy and Chemistry of the American Medical Association has presented a review of divinyl ether (1937).

Ravdin, Eliason, Coates, Halloway, Ferguson, Gill, and Cook (1938) report their further experiences with divinyl ether anesthesia. In addition to 3,407 patients receiving this anesthesia, 2,594 others were induced with divinyl ether. They find that following this type of induction, a smooth transition can be made to diethyl ether. On the basis of their present experience, in more than 6,000 cases, the above writers believe that the greatest field of usefulness of this agent is for short periods of anesthesia, with strict avoidance of anoxia.

Beach (1938) reports the satisfactory use of divinyl ether in 1,882 cases in addition to 2,632 previously reported.

Rosamilia (1938) observes that the rapid changes in anesthetic level and the tendency to increased salivation are drawbacks to divinyl ether from a dentist's viewpoint.

Trichlorethylene: The Council on Pharmacy and Chemistry of the American Medical Association has prepared a preliminary report on trichlorethylene for general anesthesia (1936).

Trichlorethylene produced anesthesia by inhalation in the rat (Krantz, Carr, and Musser [1935]). In the rat and rabbit, trichlorethylene anesthesia is accompanied by considerable stimulation of the skeletal musculature. In the rabbit the use of the agent results in a slight hyperglycemia. Trichlorethylene failed in their experiments to block nerve conductivity, on direct application; judgment was based upon persistence of blood pressure and respiratory responses to faradization.

Krantz, Carr, Musser, and Harne (1935) studied the action of trichlorethylene in rats and dogs (1935). In doses of from 1.0 to 2.0 c.c. by inhalation in dogs under ether anesthesia, trichlorethylene produced

*Miscellaneous Data Regarding the Anesthetic Action of Several Agents.**—

Cyclopropane: The present status (1939) of cyclopropane has been reviewed by the Council on Pharmacy and Chemistry of the American Medical Association. This supplements a preliminary report of 1936 by the Council.

The quantity of cyclopropane in the inspired air necessary for anesthesia, loss of reflexes, and cessation of respiration has been reported by a number of observers. Robbins set out to determine the blood concentrations necessary to produce these effects. Dogs were used.

TABLE II

REFLEXES	NUMBER OF ANIMALS	AVERAGE C_3H_6 % IN AIR	AVERAGE C_3H_6 MG. PER 100 C.C. ARTERIAL BLOOD	AVERAGE DISTRIBUTION RATIO
Loss of corneal reflex	9	18.0	13.9	0.490
Abdominal relaxation	16	22.3	16.8	0.492
Loss of wink reflex	14	27.3	20.6	0.500
Costal paralysis	14	33.6	25.5	0.497
Respiratory arrest	10	35.8	28.2	0.492

As would be expected from a comparison of the distribution ratios of ether and cyclopropane, the latter is eliminated from the tissues the far more rapidly of the two. For ether, the distribution ratio of ether between air and blood is 1:14.4 at 37°. Full equilibration is rare; usually the value is 1:10 rather than 1:14.4 (Robbins [1936]).

Modifications of Cyclopropane: Methyl cyclopropane has been prepared and tested on monkeys (Lott, Christiansen, and Shackell [1938]). On the basis of six anesthesias in three monkeys, they conclude that methyl cyclopropane does not compare favorably with cyclopropane because of transient tremors, convulsive seizures, greater postanesthetic depression, etc. They state that the lethal concentrations of the two agents are about the same. The data supplied do not seem adequate support for the conclusions reached.

Henderson and MacDonald (1937) have studied dimethyl cyclopropane and trimethyl cyclopropane. They report that with these agents more cardiac irregularities and a more persistent low blood pressure are found than with cyclopropane. These substituted agents produced a deleterious effect on cardiac contractility.

Both mono- and dichlorocyclopropanes are unsuited to anesthesia; they cause marked irritation of the lungs, according to Henderson (1938). He found edematous, collapsed, red areas in cat's lung and trachea, and bronchi contained froth in several cases. Evidence is presented that substituted cyclopropanes are instable in the body.

Propylene impurities, hexenes, and hexanes are discussed by Henderson and Smith (1936).

*For more information concerning these agents, consult sections describing effects on specific systems, such as "Circulation," etc.

thrombosis and coronary thrombosis following an interval of low blood pressure in arteriosclerotic persons might produce fatalities many days following the anesthesia. In many cases the problem of what truly represents an anesthetic death is almost hopelessly difficult.

In this series, avertin was used in a disquieting number of patients having liver or kidney disease.

Shipway (1936) describes the use of avertin in 1,600 anesthesias. Many anesthetists will not agree with his statements that "Given in accordance with established principles avertin can be used with *complete* safety" (italics by the reviewer), and that "liver and kidney disease are not contraindications to its use. . . ."

Leveuf and Boureau (1937) call attention to their observation (on 1,162 children) that they have occasionally encountered (just how often is not clear) children who appear to be abnormally sensitive to rectanol (tribromethanol) anesthesia, even to from 70 to 80 mg. per kilogram doses, the sensitivity being evidenced by notable fall in blood pressure or a shocklike state. The frequency of this occurrence was at least great enough to cause them to abandon the use of this agent when confronted by the necessity of undertaking potentially shocking operations.

Beecher (1938) has described the results of a study of seven years' use of avertin at the Massachusetts General Hospital in 3,666 patients. Seven deaths occurred in which the avertin appeared to have played an important role. In four of the cases, avertin should today be recognized as contraindicated. Even after elimination of these cases, three remain, giving a possible death rate of 1:1,200 far too high a rate.

Six of the seven patients who died showed an immediate depression after avertin with amylene hydrate was given. In the seventh the depression did not appear until the end of a short operation. Cyanosis was frequently recorded. Only one patient of the seven recovered full consciousness; one other was, at best, drowsy and confused; five did not recover consciousness. Pulmonary edema was a terminal feature in half the cases. In three cases the condition appeared strikingly reminiscent of damage due to chloroform, and one is compelled to add, reminiscent also of anoxia.

The suspicion that tribromethanol and chloroform produce similar toxic effects is not new. Tribromethanol, the chief anesthetic agent in avertin with amylene hydrate, bears the same relationship to ethyl alcohol as chloroform bears to methane. In the case of both methane and ethyl alcohol, the anesthetic action has been greatly intensified by the substitution of three halogen atoms for three hydrogen atoms. Traces of bromine have been found in the breath and the sweat after the administration of avertin. The drug is generally believed to be detoxified in the liver by conjugation with glycuronic acid and then excreted as a complex organic compound of bromine.

a lowering of pulse rate and a fall in blood pressure. The respiration was generally slowed and deepened in amplitude. Coronary experiments are said not to show any consistent change in flow as a response to the drug.

Striker, Goldblatt, Warm, and Jackson (1935) described the history of the use of trichlorethylene.

Trichlorethanol: Hewer and Belfrage (1938) have studied trichlorethanol in eighteen patients. They report that the effects of the agent are much more variable in the human subject than those of avertin. There was one death in the eighteen patients. Another patient died an hour following operation from a "thyroid crisis."

Tribromethanol (Avertin): The Council on Pharmacy and Chemistry of the American Medical Association has prepared an extensive review of published reports on avertin with amylene hydrate (1937). This supplements the preliminary report of 1930.

Mueller (1937) describes the use of avertin anesthesia in 5,019 cases. While she did not find any death to be due to this anesthetic agent, only a few of the deaths are described. The meager details supplied are not reassuring. A few of the causes of death as described follow: "Autopsy showed chronic nephritis and generalized arteriosclerosis with coronary sclerosis, massive atelectasis of the left lung and lobular pneumonia, as well as degeneration changes in other organs of the body"; "postoperative shock"; "myocardial failure"; "coronary occlusion"; "coronary embolus"; "postoperative shock"; "arteriosclerotic heart disease"; "shock was an outstanding feature, and pneumonia was a terminal condition"; "patient . . . had a stroke two days later"; "considerable mucus in the lower respiratory tract (at operation) . . . moist râles continued . . . bronchopneumonia . . . died on fifth day"; "died fourteen days postoperative with uremia and hypostatic pneumonia"; "pneumonia developed . . . toxic myocarditis . . . overwhelming toxemia . . . was the cause of death"; "coronary sclerosis . . . a lobular pneumonia, moderate pulmonary edema and a right hydrothorax"; "lobular pneumonia . . . left hydrothorax, pulmonary edema, and fatty infiltration of the myocardium." "An analysis indicates that none of these could be classified as strictly an anesthetic death." Perhaps not. Such decisions are hard enough, if not impossible, to make at times, and this reviewer is not presumptuous enough to make an attempt to label any of these deaths as due to the avertin, but he does want to take exception to the statement made in several places in the paper that "death occurred so late as to be unrelated to the anesthetic." Among other instances, this statement was made in regard to a 44-year-old woman dying of uremia and hypostatic pneumonia on the fourteenth postoperative day. Kidney damage produced by avertin might well result in a fatal outcome fourteen days following the initial injury. Deaths from cerebral

LOCAL ANESTHESIA

Reviews.—

Lundy (1936) has reviewed the established as well as the newer local anesthetics. His article makes an interesting supplement to the classic report of the Committee of the American Medical Association, "The Toxic Effects Following the Use of Local Anesthesia" (Mayer [1924]). Seevers (1939) has presented a useful review of local as well as general anesthesia. Other reviews dealing with the local anesthetic agents are by Schaumann (1938) and Cook (1938).

Methods of Evaluation.—

Tests: Following preliminary studies, attempts to evaluate new local anesthetic agents usually proceed along two lines: first, clinical, to discover if the agents in question are equal to or superior to well-known compounds in regard to efficiency of action and toxicity; and, second, to find and express any relationships between chemical constitution and pharmacologic action. When such relationships are under consideration, methods must be employed that will express the relative potencies of agents which show wide variations in intensity of their actions. Sinha (1936, a) has dealt with these problems in an attempt to determine the approximate accuracy of the chief methods used in the assay of local anesthetics:

Sinha has demonstrated the interesting fact that the addition of epinephrine to local anesthetic solutions greatly alters their relative potency (Table III).

TABLE III

EFFECT OF EPINEPHRINE IN ALTERING RELATIVE POTENCY OF SEVERAL LOCAL ANESTHETICS (HUMAN WHEAL)

DRUG	CONCENTRATION (%)	WITHOUT EPINEPHRINE HCl		EPINEPHRINE HYDROCHLORIDE 1:50,000	
		DURATION OF ACTION (MIN.)	RATIO OF ACTIVITY*	DURATION OF ACTION (MIN.)	RATIO OF ACTIVITY*
Procaine HCl	1.0	18-22	1	160	1
X	0.1	20-35	25	155	10
Y	0.25	22-27	10	160	4
Z	0.25	17-21	4	75	0.5-1.0

*The ratio of activity was calculated from the reciprocal of the concentration required to produce an action of equal duration.

X, pyrazoline derivative.

Y, Z, quinoline derivatives.

In most of the cases studied no simple linear relation between time and concentration exists; therefore, differences in local anesthetic potency cannot be estimated by measuring differences of duration of action. As Sinha points out, merely because drug A produces an action twice as long as drug B at the same concentration, it does not follow that A is twice as potent as B.

A very high degree of accuracy cannot be obtained with any of the usual tests. Their use lies in indicating gross differences in activity. Unfortunately it is not possible to obtain any absolute value for local

It has been assumed that the chloroform-like toxic effects are produced only by large doses. That this is not the case was shown by the data presented here. Although much dwelling on the chloroform analogy is not justified by the evidence at hand there are clinical, as well as theoretic data to suggest that the observed similarities in effect are more than chance.

Attention should be drawn to the fact that the great majority of the cases reported describe the use of avertin with amylene hydrate in adults. Children appear to tolerate the drug better than adults. However, death in the 12-year-old patient reported here is a reminder that children are not immune to the toxic effects of the drug.

It is useless to consider mortality figures for a given anesthetic in any but the most general terms. The data usually presented describe not the total death rate, which may not permit accurate evaluation, but rather how often the circulation fails and sudden death occurs.

It is probable that any agent which produces fatalities with the frequency of avertin with amylene hydrate must injure a great many patients whose injuries go undetected or are attributed to the patient's disease.

The ratio of deaths to anesthesias presented here cannot be considered in any precise mathematical sense.

Barbiturates: The Council on Pharmacy and Chemistry of the American Medical Association has prepared an extensive preliminary report on evipal soluble.

Garofalo (1938) has reviewed the present status of pentothal as an anesthetic agent.

Pratt, Tatum, Hathaway, and Waters (1936) report preliminary pharmacologic and clinical examination (forty-five patients) of intravenous sodium ethyl (1-methyl-butyl) thiobarbiturate. This preliminary trial justified further study, they believed.

In a study of fourteen thiobarbituric acid derivatives, Gruhzit, Dox, Rowe, and Dodd (1937) found that, while intravenous administration induces nearly instantaneous anesthesia of brief duration and quiet recovery, anesthetic doses cause considerable circulatory congestion, stasis, and oftentimes hemorrhages in the lungs, liver, kidneys, and the central nervous system. They found two agents to be worthy of clinical trial: isoamylethylthiobarbituric acid and (1-methyl-butyl) thiobarbituric acid.

Gruber and his co-workers (1938, a)* report that the sodium salts of evipal, pentobarbital, ortal, and amytal depress the cardiac vagus nerves in dogs, cats, monkeys; pentothal, thioethamyl, and thiopentobarbital may increase the responsiveness of the heart to vagus nerve stimulation.

*See also Gruber and co-workers (1938, b).

Morrison (1938) describes the use of eucupin, 1:1,000 to 1:500, in 1 per cent procaine to relieve the pain for from twenty-four to forty-eight hours following tonsillectomy. The drug may be used in ointment form to control itching and soreness of the skin.

Laszlo and Hauck (1938) have used an eucupin-procaine solution for local anesthesia in 300 tonsillectomies. They used eucupin in 0.1 per cent solution for the first 100 cases. Since then they have found 0.2 per cent solution more satisfactory, in each case with 1.0 per cent procaine and with epinephrine added. Many patients were free from discomfort for twenty-four hours, and a few for forty-eight hours. They encountered no local tissue reactions; no general toxic symptoms have appeared. Healing has not been delayed.

Hirsch (1938) recommends the use of eucupin-procaine solution in nerve-block anesthesia for tonsillectomy. He has used 0.1 per cent in twenty cases and 0.2 per cent in the last thirty cases. Anesthesia lasts for an average of twenty-four hours.

Irwig (1938) recommends the use of eucupin oil injections in treating acute and chronic low back pain in more than 100 cases. He has observed no undesirable aftereffects. The oil is injected intramuscularly on one or both sides in from 1.5 to 2.0 c.c. amounts, rarely more. Following injection, the area is massaged forcefully. The paper does not make clear the duration of the anesthesia. In another paper (1939), he again recommends the use of eucupin (0.1 per cent) in oil (sweet almond oil, or iodized oil to show on x-ray) in treating low back pain.

Bowman (1938) has used isoamylhydrocupreine, eucupin 1:500 plus 1 per cent procaine with satisfaction in treating lesions of the anorectal region. Little sensation returns for from two to three days following the injection. He states that isoamylhydrocupreine can be boiled and that it is compatible with epinephrine. It is water-soluble and can be used in Ringer's solution or in normal saline solution. He states only that he has used it for six months; the number of cases is not given.

Eucupin blocks (0.1 per cent solution with 1.0 per cent procaine) are being used with considerable satisfaction to relieve the postoperative pain of anorectal surgery at the Massachusetts General Hospital. It has also been used to obtain prolonged block of sympathetic nerves. In such cases it is used with considerable caution, for there is some danger of sloughs with agents of this nature.

Nupercaine in Oil: Simmons (1936) recommends the use of nupercaine in oil injected locally to give a prolonged anesthesia for hemorrhoidectomy. This anesthesia, he says, persists throughout the major part of the convalescence, from seven to ten days. Local infection is listed as a contraindication. Fear of sloughs or abscess development in

anesthetic potency. Relative values, however, can be expressed; but these appear to be valid for only a given set of experimental conditions. Probably the simplest method for comparing relative potency of local anesthetics (Sinha) is to measure the concentrations which produce local anesthesia for some standard time. The rabbit's cornea method or the wheal method can be used.

Toxicity: The local anesthetic activity of an agent is significant only when considered in conjunction with its toxicity. The lethal effect of a local anesthetic agent upon mice is inadequate for a consideration of toxicity even in that animal. This must be supplemented by information as to drug effects upon vital centers. For example, cats anesthetized with chloralose can be used to study the drug effects on blood pressure and respiration. Sinha's article (1936) is a good example of a detailed study of toxicity of local anesthetic agents. One requirement of a good local anesthetic agent is that it be nonirritant in the necessary concentrations. When the rabbit's cornea method is used, points for consideration are vascular engorgement, pitting of the cornea, and conjunctival edema. With the wheal method, hyperesthesia, redness, and edema of the wheal are important.

Clinical Use of Long-Lasting Local Anesthetic Agents.—

Eucupin: Eucupin (isoamylhydrocupreine) (Morrison [1938]), a synthetic alkaloid closely related to quinine and usually employed as the dihydrochloride, is a fine, white crystalline powder with a very bitter taste, soluble in fifteen parts of water and in alcohol. Alkalis precipitate it. The pharmacologic action of eucupin resembles that of quinine. Large doses of its salts stimulate the vagus and the medullary respiratory centers. Perfusion experiments indicate that the drug causes relaxation of smooth muscle. It diminishes the pressor effect of epinephrine; therefore, when eucupin is used as a local anesthetic, somewhat more epinephrine must be added than with other anesthetics if capillary ooze is to be reduced.

Direct application of eucupin, 1:1,000 solution, paralyzes sensory nerve fibers. Absorption following hypodermic injection is very slow, sometimes requiring days. It is destroyed in the body. It has bactericidal powers (Morgenroth), and is said to destroy hemolytic streptococci in 1:40,000 dilution, and *Staphylococcus albus* in 1:16,000 dilution.

While eucupin is an efficient local anesthetic agent, its action is slow because of slow diffusion. Before anesthesia is produced it may give rise to a burning sensation and may, therefore, be used in conjunction with 1 per cent procaine. Solutions of eucupin stronger than 0.2 per cent probably should not be used (Morrison) because of the danger of tissue injury. Idiosyncrasy is sometimes observed as it is with other quininelike compounds.

amine groups are superior in their anesthetic effects to side chains containing a single amine group.

Edwards (1936) describes his use of Finsterer's technique for producing splanchnic anesthesia as a preliminary to gastric surgery. He considers it indicated as the anesthesia of choice in aged or debilitated patients, for surgery for hematemesis, and as anesthesia on trial in routine gastric cases. To him, the chief disadvantage is the tendency of the patients to develop ileus; four of fourteen gastrectomies developed subacute dilatation of the stomach.

Splanchnic block has been used with considerable satisfaction by Allen (1940) in gastric surgery at the Massachusetts General Hospital.

Maxeiner, Sedgley, and Culligan (1934) recommend the use of anterior splanchnic block coupled with local anesthesia when it is discovered that the surgery contemplated will require a longer time than the spinal anesthesia already in effect will last. The splanchnic anesthesia should be induced before the spinal anesthesia wanes.

Procaine: Leriche has, in the past several years, produced a veritable snowstorm of brief papers concerning the various uses of nerve-block anesthesia in treating a variety of conditions, from sprained ankles to subdeltoid calcifications. His papers are based upon the following reasoning: "In articular traumatism (for example) there is no lesion of the ligament per se, but rather one in the nerve endings in these ligaments. These terminal twigs are the sensory origin of the reflex that ensues, and it acts upon the articular trophism and on the vascularization of the . . . muscles. The rationale of the procedure is to block the sensory nerve endings, thus stopping the abnormal excitation. This breaks up the reflex by interrupting the vicious cycle arising from the vasodilatation which in turn has been constantly re-exciting the sensory nerve endings." A few specific references follow.

Leriche (1937) has stated the "rules" for therapy of articular fractures by procaine hydrochloride infiltration of ligaments and immediate active mobilization.

Kiser (1936) reports the use of procaine (10 c.c. of 2.0 per cent plus 1:50,000 epinephrine) injected into the painful periarticular space in cases of sprained ankle, with successful results in six, and unsuccessful in one. This is based primarily upon the work of Leriche.

Jung and Christèas (1938) report the use of procaine infiltrations in treating three cases of fractures of the vertebral column.

Leriche and Jung (1938) describe the treatment of subdeltoid calcification by novocain infiltration, with disappearance of the calcium deposit.

Goinard (1935) describes the relief of edema caused by phlebitis when the lumbar sympathetics were injected.

Ochsner and DeBakey (1939) describe the treatment of thrombophlebitis by novocain block of the sympathetics. They follow Leriche in believing that the clinical manifestations in thrombophlebitis are

even the "clean" cases will prevent many from using this technique. Block, Greene, and Wiltrakis give more specific data on this point in the following article.

Block, Greene, and Wiltrakis (1938) report the use of nupercaine in oil for the alleviation of postoperative pain in 100 hemorrhoidectomies. It is not used for the operative anesthesia. One patient had a loss of sphincter tone for seventy days. Anesthesia lasted about two weeks in most patients. There were twelve complications in 100 cases: five painful indurations with slough; five "chemical abscess formations"; "one severe case with extensive involvement of the perianal and rectal regions culminating in the formation of a bilateral ischiorectal abscess, with extension into the perineum. . . . He became extremely toxic, . . . gradually subsided after an illness of two months"; one patient developed edema of the rectal mucosa immediately after injection of the nupercaine in oil. Excluding the long case described above, the duration of complications averaged 28.9 days in duration.

If this list of twelve complications in 100 hemorrhoidectomies does not contraindicate the method to most readers, several contraindications are appended: Acute abscesses or suppurative processes around the anal canal or rectum, sloughing piles, diabetes, debilitated conditions, syphilis.

Miscellaneous.—

Tuohy (1939) finds that metycaine used for blocking individual nerves produces anesthesia quicker, and it lasts about 50 per cent longer than that produced by procaine. For injection 1.0 per cent is used; for topical application, from 2.0 to 4.0 per cent. On intravenous injection metycaine is two or three times more toxic than procaine.

Green (1937) describes the use of anucaine in oil (4.0 per cent butesin, 5.0 per cent benzyl alcohol, 1.0 per cent procaine, and 90 per cent sweet almond oil) for anorectal surgery. Although he finds it satisfactory, he reports among other complications in the 273 cases, two cases of prolonged sensory anesthesia (one and three months), one of superficial necrosis, and two with deep abscesses.

Woodbridge (1938) has considered some of the important minor points in local anesthesia. He particularly stresses the use of small quantities of vasoconstrictor solutions with the local anesthetic agent.

Sievers and McIntyre (1938) have studied the toxicity and potency of ten new benzoyl derivatives. Four of these local anesthetics merit further study. They point out the inadvisability of using subcutaneous injections of new local anesthetics in an effort to determine anesthetic potency. The surface anesthesia resulting from this may not give a true indication of the strength of the agent.

Quinoline compounds having a basic side chain of "adequate length" in position 8, Sinha (1936, b) finds, produce a strong local anesthetic action both on application to mucous membranes and when applied intradermally. He also shows that side chains containing two

due largely to the vasomotor reflex which originates in the thrombosed segment, and that the symptoms can be completely relieved and convalescence shortened by blocking the sympathetics, and breaking the reflex. They believe that the manifestations are due less to the associated venospasm than to an arteriospasm.

Rovenstine (1939) has used block of the intercostal nerves in the treatment of fractured ribs, with great relief of pain and muscle spasticity.

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studied this in dogs, cats, and rabbits, and they find that, under circumstances of depression such that the respiration is being maintained by impulses arising in the carotid sinus or the aortic arch and due to anoxemia, any events which interrupt these impulses, such as denervation of the carotid sinus and aortic arch or breathing of oxygen, may result in respiratory failure. This phenomenon could not be elicited under all types of depression but chiefly appeared under phenobarbital, phenobarbital and morphine, under pentobarbital, and under chloralose in large dosage.

Under chlorbutanol or urethane little or no oxygen depression could be produced.

If the anoxia leads to hyperventilation, CO_2 may be thrown off to such an extent that, when oxygen is supplied and the anoxia relieved, the respiration fails from low CO_2. Marshall and Rosenfeld have shown in these experiments that, even when CO_2 is inspired (5 to 7 per cent), oxygen still produces a respiratory depression and apnea.

Depression of respiration by oxygen in depressed persons is illustrated by clinical cases of Burstein and Rovenstine (1939).

Sensitivity to Low Oxygen Tension.—

Dogs were anesthetized with chloralose by Binet and Strumza (1937) and then subjected to various low oxygen tensions in the air breathed. The variations of resistance to the anoxia encountered are directly related to the degree of anesthesia of the animal. A deep anesthesia carries with it a particular vulnerability. The nearer the animal approaches awakening, the more its resistance to anoxia increases.

Some have thought that, since the respiratory exchange diminishes with deepening anesthesia and reduction in metabolic activity occurs, the organism was less sensitive to oxygen shortage during anesthesia than normally. Against this belief, Binet and Strumza (1937, 1938) state that as a result of their studies they have come to the conclusion that deep anesthesia produces in the organism a particular sensitivity to diminution of oxygen tension in the inspired air. They have used 110 dogs under chloralose.

TABLE IV

	INSPIRED AIR OXYGEN TENSION (%)	THEORETIC ALTITUDE (METERS)
Less than 45 minutes after the injection of the anesthetic, respiratory arrest occurs at:	4.67	11,000
At 120 minutes after the injection of the anesthetic, respiratory arrest occurs at:	3.39	13,000
At 240 minutes after the injection of the anesthetic, respiratory arrest occurs at:	2.41	15,000

The large series of dogs diminishes the hazards of the doubtlessly great variations in response to low oxygen tensions of the individual subjects. Dogs appear to be considerably tougher than men in withstanding low

oxygen tensions. Of course, not only the tension at which failure of the respiration occurs, but also the length of time a given tension can be withstood, is important. Binet and Strumza found that resistance increases as the anesthesia lightens. An abrupt increase in resistance occurs only when most of the chloralose has been eliminated. They have attempted to control vagal and carotid sinus effects and conclude that general anesthesia (chloralose) has a direct action upon the respiratory center; the deeper the anesthesia, the more easily anoxia precipitates respiratory failure.

Carbon Dioxide.—

Waters (1936) has described the history of the CO_2 absorption technique. A prolonged experience of trial and error has been responsible for the approved form of soda-lime containers now in use. The guiding criteria here are: lack of resistance to breathing, maximum absorption of CO_2, and complete homogeneous utilization of the soda lime with corresponding long life of the canister. In the successful clinical application of the carbon dioxide absorption technique, three factors stand out for consideration: (1) A free airway from alveoli to breathing bag is necessary; (2) leaks must be avoided; and (3) the dead space of the system should be reduced as far as possible.

Advantages of the CO_2 Absorption Technique: Waters (1936) has ably summarized the advantages of the CO_2 absorption technique, and he calls attention, among other points, to: (1) Breathing bag proximal to patient's head allows good view and easy moving of patient (to-and-fro filter); (2) fire hazard reduced when cautery used; (3) surgical team spared dulling anesthetic vapors; (4) waste of anesthetic agents used cut to a minimum; (5) better and more physiologic control of patient effected. The patient breathes a warm moist vapor, not a cold dry one, and body temperature is less apt to fall; (6) respiration, of paramount importance as sign in anesthesia, can be studied as to character, rate, and minute volume.

Disadvantage of the CO_2 Absorption Technique: The inexperienced or dull anesthetist may get into trouble through ignorance or carelessness.

Abuses: First, the quiet breathing usual with the absorption technique may permit slight degrees of respiratory obstruction to go unobserved by the careless, with considerable physiologic disturbance. Second, the deliberate use of high CO_2 atmospheres is dangerous, and, third, some apparatus has too much resistance to breathing.

Lundy, Tuohy, and Adams (1938) state that synthetic carbon dioxide has been used as a respiratory stimulant in 84,202 cases and that "if untoward results were due to the use of this gas, they have not been evident to us, and in many instances it has been used to advantage."

As Waters points out, it is important to remember that CO_2 is a waste product of the body's metabolism, and that preliminary medication, anesthetic agents, and anesthesia technique in many cases are respon-

sible for conditions which result in a rise in the body's CO_2 content, whether through respiratory depression or increase in the respiratory dead space. The anesthetist should be aware that excess CO_2 produces a rise in blood pressure; hyperpnea occurs, followed by a fall in blood pressure and depression of the respiration, and unconsciousness occurs. Apnea appears. If hyperpnea and a rise in blood pressure do not follow the administration of CO_2 (unless the subject is deeply anesthetized), an overdose is probably present.

The experimental work of Seevers, Waters, and their collaborators has shown that acapnia is not the usual cause of surgical shock as has been taught by Yandell Henderson.

This article also calls attention to the fairly well substantiated point (cf. Heymans) that the use of CO_2 in the inspired air of persons having considerable vasomotor paralysis (cf. spinal anesthesia) is dangerous, for, here, the central effects of CO_2 are lost in the paralyzed area and the local effects of CO_2 on the vessel walls result in their dilatation and a fall in blood pressure.*

Attention is called to the dangers of postanesthetic hyperventilation with oxygen and CO_2. Both oxygen and CO_2 are so rapidly absorbed from the alveoli that, when the CO_2 stimulus is removed, or if the alveoli become blocked temporarily (or permanently) by mucus, collapse is likely to occur due to absorption by the blood of the contained gases. If such hyperventilation is to be carried out, air should be utilized. Then a high percentage of slowly absorbed nitrogen remains in the alveoli, and the tendency to atelectasis is minimized.

Helium in Anesthesia.—

Sykes and Lawrence (1938) find that with a constant obstruction in the airway about twice as much time is required to "breathe to the exhaustion point" when a helium-oxygen mixture is used as when air is breathed. They did not state whether the subjects used were aware of which mixture was being employed. This knowledge might unconsciously be a factor. They recommend the use of a helium-oxygen mixture during anesthesia when a respiratory obstruction is present or when it is essential to spare as much muscular effort as possible.

Eversole (1938) reports the use of helium in more than one hundred cases, generally for the relief of respiratory obstruction. Although only infrequently indicated, he reports it to be of considerable value in cases of postoperative tracheal edema, compression of the trachea by postoperative hemorrhage, during laryngospasm, and as a breathing aid during partial respiratory paralysis such as that caused by spinal anesthesia.

Barbiturates and the Patency of the Glottis.—

Burstein (1937) and Burstein and Rovenstine (1938) report that the closure of the glottis following the intravenous administration of

*See also Smith et al. (1939).

several short-acting barbiturates (sodium thioethamyl, evipal, amytal, nembutal, pentothal) in cats is due to stimulation of the parasympathetic division of the autonomic nervous system.

The injections of the agents were made under standard conditions. When most of the animals coughed, sneezed, or hiccuped during the course of the anesthesia, cyanosis and dyspnea would quickly follow. Inspection of the glottis showed spastic adduction of the vocal cords. Where no spontaneous coughing occurred, inspection of the glottis showed hyperactive, adducted vocal cords. Lifting the epiglottis caused complete spastic closure of the glottis; cyanosis and cardiac failure ensued unless tracheal intubation was carried out.

TABLE V

AGENT	NUMBER OF ANIMALS	SPONTANEOUS LARYNGOSPASM	HYPERACTIVE LARYNGEAL REFLEX FOLLOWED BY LARYNGOSPASM
Sodium thioethamyl	37	36	1
Evipal	10	7	3
Amytal	10	4	5
Nembutal	10	6	4
Pentothal	11	8	3

Atropin (3 to 5 mg. per kilogram intravenously) always caused immediate relaxation of the cords, normal respiration, and a shortening of anesthesia time.

An explanation is thus offered for the rarity of such occurrences following heavy atropine or scopolamine premedication, known to depress the parasympathetic system. When obstruction of the airway occurs during barbiturate anesthesia, of most importance is the immediate introduction of an intratracheal tube and the provision of adequate oxygen.

The Mechanism of Anesthesia Accidents in Sublingual Phlegmons.—

Weese (1939) has studied experimentally the role of the carotid sinus in the mechanism of anesthesia accidents in sublingual phlegmons. When, for example, evipal was administered to an animal having a characteristic abscess, no untoward event occurred provided the abscess was undisturbed. Subsequently, when a dog with a sublingual abscess had received one-half of the lethal dose of evipal and light pressure was applied to the abscess immediately after the injection, respiratory failure developed at once. Neither prolonged artificial respiration nor analeptics counteracted this failure. In later experiments, when pressure was applied to the abscess five minutes after the injection of an almost lethal dose of evipal, the course was normal.

In another experiment, a dog was given a 60 mg. (per kilogram of body weight) dose of evipal. Pressure on the carotid sinus on the healthy side barely influenced the respiratory rate; but pressure on the abscessed side led to a reflex stoppage of respiration. The healthy side

was pressed again, and no respiratory effect was observed. Four minutes after the injection of evipal, pressure on the abscessed side was followed by only a slight respiratory effect.

Evidence is offered that the effects observed are not due to a pain reaction.

When the carotid sinus is denervated as a preliminary to the above studies, pressure on the abscess does not lead to apnea.

The following explanation by Weese is offered on the basis of these and many other similar studies: "If an abscess develops in the area of the carotid sinus, the nerve elements become more sensitive than normally when a certain stage of inflammation is reached. Should one then stimulate the nerve elements, the physiologic inhibition on the respiratory center, which continually acts on the center through perceptive nerves from the carotid bifurcation, will be greatly intensified. Consequently, pressure on such an altered area gives rise to a temporary or permanent respiratory failure with corresponding change in blood pressure, instead of only a transitory inhibition. However, this hypersensitivity diminishes during the course of anesthesia. If the anesthesia is deep enough, it vanishes completely. . . . This gradual disappearance of the respiratory reflex seems to me to be due to the slowly induced anesthesia of the nervous elements in the carotid bifurcation itself." The anesthesia of the carotid sinus appears to lag behind the anesthesia of the central nervous system.

Ether anesthesia depresses the vagus system much more than do the barbituric acids. Probably this explains why in sublingual phlegmons accidents are more common under barbiturate anesthesia than under ether. However, if intravenous evipal is to be used, anesthesia deep enough to paralyze the vagus completely must be employed, and, furthermore, the operation should not begin until at least five minutes after the injection so that the vegetative nervous system is also certainly anesthetized.

Miscellaneous Points.—

Flagg (1937) gives an interesting historical review of the intratracheal technique in anesthesia. He describes the technique and presents the arguments for and against it.

Flagg (1938) makes a plea for the integration of anesthesia, resuscitation, and oxygen therapy, to be called pneumatology.

Peoples (1938), in studying the effects of diethyl and divinyl ether (vinethene) upon the oxygen consumption of rats, finds that oxygen uptake increases with both agents under light anesthesia. Also, with both agents there is a reduction in oxygen consumption during deep anesthesia, greater in the case of ethyl ether. Peoples observes that there seems to be a critical depth of anesthesia below which the rate of oxygen consumption abruptly falls, perhaps indicating a sudden change in

cellular metabolism of most of the body. Certainly it is unlikely that the oxygen consumption of any one type of tissue could fall enough to reduce the total metabolism by 50 per cent.

In 1934 Guedel and Treweek presented a paper on ether apnea. Burford (1937) reports his experiences with deliberately induced apnea during anesthesia. He finds it useful and safe in so far as he has observed.

Lawrence (1937) points out that, whereas the pharmacopeia allows 5 per cent free N_2 in N_2O, some gases contain as much as 15 per cent free N_2, thus reducing the anesthetic power and the oxygen allowable.

Harris (1937) has considered from the physiologic point of view the deliberate use of anoxia in anesthesia, and, in particular, "secondary nitrous oxide saturation" which he heartily condemns as do most anesthetists now that the evils of anoxia have been so clearly demonstrated.

Lunsgaard and Van Slyke have shown that reliance on cyanosis as a clinical guide to anoxia is unwise, for the appearance of this sign depends upon the presence of a certain quantity of reduced hemoglobin in the blood and not upon the relative proportions of reduced and oxygenated blood. In one person this sign may appear with relatively small alteration in oxygen saturation, but not appear in an anemic person except in advanced asphyxia, or perhaps not at all. Subclinical anoxia can exist without cyanosis and yet be of a degree that would be injurious, if prolonged.

Shaw, Steele, and Lamb (1937, a) have observed the effect of cone ether anesthesia on the blood oxygen of dogs. During this study they have found a progressive increase in the oxygen capacity of the arterial blood and a decrease in the oxygen saturation of the arterial blood. The findings indicate the existence of an anoxic anoxia; whereas under spinal anesthesia (1937, b) an increase in the oxygen saturation of the arterial blood was found, with a decrease in the oxygen content and saturation of the venous blood and an increase in the arteriovenous oxygen difference. The changes indicate the existence of a stagnant anoxia.

THE CIRCULATION AND ANESTHETIC AGENTS

The Effects of Various Agents Upon Cardiac Automaticity and Output.—

Cyclopropane (Including some comparisons with ether and chloroform): An early question to raise concerning any anesthetic agent is, what are its effects upon the heart? Cardiac irregularities during anesthesia have caused much concern, but rarely has this concern led to a controlled study of the phenomenon. Recognizing this, Meek, Hathaway, and Orth (1937) have made an excellent study of the effects upon cardiac automaticity of a sudden strain placed upon the heart, effected by means of a test dose of epinephrine under ether, chloroform, and cyclopropane.

As the authors point out, further studies of other cardiac properties are desirable, as, for example, the effects of the agents upon irritability, strength of contraction, length of refractory period, and conduction rate in the myocardium itself.

Long ago Levy showed that chloroform might sensitize the cat's heart to certain stimuli that lead to ventricular fibrillation. This possibility must be considered for each new anesthetic agent. Much information indicates that observations upon heart effects in animals cannot summarily be applied to man. Great stress is often laid upon the difference in the response of dogs and cats to epinephrine during chloroform anesthesia. Meek and his associates state, "All the evidence with which we are familiar indicates that conclusions from experiments with anesthetics on the dog may be applied to man with much more certainty than those from the cat." Weidenhorn, Volini, and McLaughlin (1938) agree that dogs are more desirable than cats for cardiac studies of the anesthetic agents, for the electrocardiogram of the dog has great similarity to that of man. Admittedly it is more difficult to produce ventricular fibrillation in dogs under chloroform than in cats by the injection of epinephrine.

Judging (Meek and associates) by the appearance of tachycardia after epinephrine injection, cyclopropane has an even greater sensitizing effect upon the ventricular automatic tissue than does chloroform.

In ether anesthesia it was found (Meek and associates) that auriculoventricular nodal rhythm is common after the injection of adrenalin, whereas chloroform favors ventricular extrasystoles, nodal and ventricular rhythms, and occasionally ventricular tachycardia and fibrillation after large doses of epinephrine. Weidenhorn, Volini, and McLaughlin (1938), as have others, have found similar effects from chloroform. Ventricular extrasystoles, auriculoventricular nodal rhythms, fast ventricular rhythms, tachycardia, and, on occasion, ventricular fibrillation occur under cyclopropane.

It is well known that ventricular fibrillation is more likely to occur during light chloroform anesthesia than during deep. Under cyclopropane, most cardiac disturbances appear under deep anesthesia. The fact should not be overlooked that cardiac disturbances also can appear under light cyclopropane anesthesia. For example, Meek and his associates found that, under their test conditions, eleven of seventeen dogs developed tachycardia under light anesthesia, no small percentage. The arrhythmia here was of shorter duration than it was under deep anesthesia.

Taylor, Bennett, and Waters (1937) state, "Disturbances of pulse rate and blood pressure have in our experience occurred more often with cyclopropane than with other inhalation agents."

Twice as many arrhythmias are found to be present under cyclopropane as under ether. The character of the arrhythmias is of considerably more importance than the number. When it is recalled that cyclopropane anesthesia, in distinction to ether, leads to the appearance of an ominous type of irregularity, multiple focus ventricular extrasystoles which on occasion come in runs and sometimes finally end in ventricular fibrillation and death, a possible hazard of deep cyclopropane anesthesia becomes evident, and this perhaps offers an explanation of the sudden deaths of able-bodied persons under cyclopropane anesthesia.

While these facts are not adequate to label cyclopropane as an impossibly dangerous agent, they certainly indicate that constant, meticulous observation of the heart must be carried out during anesthesia under the agent. Careless disregard of reasonable warning signs may lead to the abandonment of an agent which has outstanding merit in some of its other qualities.

The use of epinephrine (and probably other sympathomimetic drugs) is absolutely contraindicated in cyclopropane anesthesia.

A number of sudden deaths of patients during cyclopropane anesthesia offers a sharp warning of the desirability of further cardiac studies under this agent.

Robbins and Baxter (1937) have studied electrocardiograms of dogs under cyclopropane anesthesia and have correlated them with the arterial concentrations of oxygen, carbon dioxide, and cyclopropane. In only one experiment (? lf 13) did cardiac irregularities appear until some minutes after respiratory arrest; following this, auriculoventricular block, nodal rhythm, and multiple focus tachycardia and fibrillation were variously observed. When the cardiac irregularities began, the arterial blood oxygen content was very low, on the average only 2.8 volumes per cent. The arrhythmias disappeared when artificial respiration restored a normal blood oxygen level. Under these circumstances it was possible to increase the blood concentration of cyclopropane by as much as 30 per cent over the amount necessary for respiratory arrest, without heart damage, as judged by electrocardiographic records. Robbins and Baxter conclude that the cardiac irregularities which develop at about the time of respiratory arrest are not due to a cardiac effect of cyclopropane but to the extreme anoxia. This conclusion is based upon two points: (1) under artificial respiration a high blood concentration of cyclopropane can be built up without cardiac arrhythmias; and (2) it has been found by a number of observers that irregularities similar to those recorded here apparently can be produced by anoxia. It was found that, if cyclopropane were increased sufficiently, cardiac arrhythmias and failure ultimately resulted, probably due to direct action of cyclopropane upon the heart.

Evidence that some of the cardiac effects of anoxia are due to stimuli from the medulla is found in the fact that there are some differences in the dogs with intact vagi and those in which the vagi have been severed. In the latter group the lack of increase in the P-R interval and the absence of severe degrees of auriculoventricular block are characteristic. On the other hand, ventricular extrasystoles, nodal rhythm, and multiple focus ventricular arrhythmia were found in each group at about the same degree of anoxemia. Not all of the arrhythmias, during respiratory arrest then, are of vagal origin.

Robbins and Baxter (1938) have determined the cardiac output in dogs according to the Principle of Fick. They found that the output increased in nine dogs under moderate surgical anesthesia with cyclopropane; it equalled the normal in four dogs under very deep anesthesia; and it decreased 28 per cent in five dogs under very deep anesthesia.

The Barbiturates: Thiobarbiturates in clinical medicine are represented chiefly by pentothal.

Gruber (1937) first drew attention to changes produced by the thiobarbiturates in the electrocardiogram of dogs. Volpitto and Marangoni (1938) carried out similar studies in man.

Gruber found that the first injection of pentothal produced disturbances in the electrocardiogram in most cases in dogs and that the second injection was always followed by disturbances such as alternate ventricular rhythm, premature contractions, and shortened P-R intervals. Similar observations were made in cats, rabbits, and monkeys. Morphine enhanced the appearance of these disturbances, while atropine was without effect. Epinephrine removed them temporarily or permanently.

Kohn and Lederer (1938), studying cats, dogs, rabbits, and monkeys, found that not all the animals observed showed significant electrocardiographic changes following the induction of pentothal anesthesia. Another group showed disturbances such as ectopic beats, alternating normal and premature rhythm, and disturbances in intraventricular conduction. In some animals the P-R interval was shortened. This is not in agreement with the observations of Betlach (1937, 1938), Hafkesbring and MacCalmont (1938), and Volpitto and Marangoni (1938).

Hafkesbring and MacCalmont (1938) object that they have been unable to find any work in which the effects of the barbiturates upon the electrocardiogram were not masked by the use of other anesthetics (cf. Gruber); accordingly, they have studied the electrocardiograms of dogs and cats before, during, and after administration of the drugs (from one-third to one-half the fatal dose at intervals of from one to two weeks) in an attempt to determine the effect upon the myocardium during anesthesia, the degree to which the electrocardiogram returned to normal with the animal's recovery, and the presence or absence of cumulative effects.

They state that earlier work has shown no tolerance in dogs and cats for the barbiturates; they refer to Eddy and state that they confirm these findings. However, these may be compared with other data in the section on "Tolerance to Barbiturates."

Hafkesbring and MacCalmont conclude that the only cardiac effects of anesthetic doses of barbital, amytal, and nembutal, as indicated by the electrocardiogram, were an increase in heart rate and a decrease in sinus arrhythmia. Complete recovery, as far as the electrocardiogram could indicate, was found on the day following administration of the drugs.

Volpitto and Marangoni (1938) found in seventeen clinical trials that the electrocardiogram showed no deviation from normal in the QRS wave, P-R interval, or T wave under pentothal, sodium thioethamyl, or evipal anesthesia.

Betlach (1937) carried out repeated electrocardiographic studies on dogs over a considerable period of time and found that some variation in the electrocardiogram occurs from day to day in the control series, one or two of the variations being frequently found. His statement that sodium amytal and pentothal sodium caused no changes of significance in the electrocardiogram does not agree with the findings of others (Gruber [1937], Kohn and Lederer [1938]).

Betlach (1938), on the basis of rather scant data, concludes that there is some evidence at least that electrocardiographic changes caused by barbiturates may result primarily from anoxia. This matter is of importance, and much more information must be available before one can conclude that the intravenous barbiturates can be used with *safety* in patients with heart disease. At the Massachusetts General Hospital, after the use of several thousand administrations of intravenous barbiturate anesthesias, the opinion is still held that these agents should not be employed in the presence of heart disease, particularly of the myocardial or coronary type.

The great variation in response so often encountered when the barbiturates are used has been widely recognized as a hazard of the use of these agents. Less widely known is the possibility of a hazard of intermittent dosage during a given anesthesia. Veal and Reynolds (1938) have called attention to this in a paper on the subject.

Their studies were made on dogs and cats. An initial intravenous dose of 20 mg. per kilogram of body weight of pentothal sodium produced a sleeping time of from seven to twenty minutes. As soon as various reflexes had returned, additional doses of from 3 to 5 mg. per kilogram were given. The duration of anesthesia increased. It lasted from forty to fifty minutes. Finally, they report that, without any indication from the blood pressure or respiratory rate (both were continuously observed), an additional fractional dose would produce death.

In another series of experiments the same initial dose was given and produced an anesthesia averaging twenty minutes in duration. As soon

as the reflexes had returned, the same dose was repeated. A much more profound anesthesia ensued, and some of the animals died. These experiments suggest that the animals could break down to a less toxic form only a certain amount of the agent, or, it seems more likely to this reviewer, that the system still contained a considerable quantity of incompletely detoxified breakdown products, capable of acting with the freshly added agent to produce profound anesthesia. Or it might be suggested that the organs had been so weakened by the initial dose that they were less able to tolerate the same-sized dose. It is clear from these and other experiments that reawakening and return of some reflexes do not indicate that the action of these drugs is complete. It is plain that the intermittent use of these agents cannot be likened to the intermittent use of, say, ether anesthesia. An ominous fact to be observed is that with each fractional dose of the barbiturate, the margin of safety becomes less. A lethal dose may be administered without adequate warning from respiratory, circulatory, or reflex changes, according to Veal and Reynolds. Pentothal sodium does not seem to be a safe agent for prolonged anesthesia, even if administered by the fractional method.

Reynolds and Veal (1938), in studying the effects of pentothal sodium in dogs and cats, observed that sudden moderate overdosage first produces cessation of respiration, but that, with continuous administration of small amounts, though only enough to maintain light anesthesia, signs of heart muscle poisoning appear. The longer the administration is continued, the more the danger seems to shift to abrupt failure of the circulation, without warning.

Lundy, Tuohy, and Adams (1937) state that intravenous barbiturates are not as safe in children under 10 years of age as in adults.

Tournade and Joltrain (1936) have considered much literature dealing with the cardiac and respiratory effects of evipan.

Nowak (1938) states that evipal, pernocton, amytal, and avertin depress the reflex activity of the carotid sinus pressor mechanism but do not necessarily abolish it. Evipal and amytal gave, in his studies on dogs, the most consistent results with fair pressor responses. He concludes that these drugs cannot be considered ideal for vasomotor studies chiefly because of their depressing effect upon vasomotor reflexes.

Holman and Page (1938) have studied the cardiac output in arterial hypertension (produced by constricting the renal arteries) in unanesthetized dogs as well as in dogs anesthetized with pentobarbital. They found that the cardiac output was not changed by the development of hypertension. The high blood pressure could, it seems, have arisen only through the mechanism of increased peripheral resistance. Light pentobarbital anesthesia did not change the cardiac output of either normal or hypertensive dogs; but when the anesthesia was deep enough

to depress the respiration, the pulse rate increased as did the cardiac output. Insufficient data to establish this are presented. It is recorded that marked cyanosis was present under deep anesthesia, and the inference is drawn that the anoxemia is responsible for the increased cardiac output. It is regrettable that these observations were complicated by anoxia.

Tribromethanol (Avertin): Morton (1935) observed seven patients with normal hearts and four with heart disease before, during, and after avertin anesthesia. The most frequent electrocardiographic change seen was an alteration in the form of the T wave. There was usually a decrease or reversal of potential, suggesting a change in the activity of the myocardium at the base of the ventricle, perhaps due to a direct action of the drug on the heart, to cardiac anoxia, or to lessening of demands made upon the heart. Electrocardiograms of the isolated, perfused frog's heart showed that avertin depressed the muscle, but had little action on the pacemaker.

Miscellaneous Agents: Widenhorn, Volini, and McLaughlin (1938) have studied in dogs the electrocardiographic effects of these general and local anesthetics: ether, chloroform, avertin, nembutal, amytal, pentothal, evipal, paraldehyde, and procaine. They found that ether produces little change in the tracings; the most noticeable effect is pronounced sinus tachycardia. Chloroform produced profound changes, nodal and ventricular extrasystoles, a prolonged P-R interval, and bradycardia. Local anesthesia alone produced no changes. In general, they find the influence of anesthesia upon the electrocardiogram to be: "(1) Removal of vagal tonus with possible sympathetic stimulation. (2) Action on the intrinsic conduction system producing a delay in impulse transmission. (3) Induction of premature contractions of nodal and ventricular origin. (4) Possible anoxic factors influencing the heart muscle and the coronary circulation directly."

The paper by Chiariello (1937) contains further information.

Ventricular Fibrillation.—

It is well known that under suitable conditions the injection of epinephrine into an animal under chloroform anesthesia will be followed by ventricular fibrillation and death. The cause of the fibrillation is not known. It has been suggested that chloroform alters the susceptibility of the myocardium so as to make it more susceptible to fibrillation, while epinephrine increases further the cardiac irritability and precipitates fibrillation. The epinephrine also increases the load on the heart by increasing the peripheral vascular resistance. It has also been suggested that this precipitates the fibrillation of the altered heart.

Shen and Simon (1938) find that ventricular fibrillation frequently occurs in dogs* when epinephrine is injected into them during light chloroform anesthesia. Procaine given intravenously to dogs (from

*See article by Meek and associates.

4 to 5 mg. per kilogram) with the epinephrine during light chloroform anesthesia has a protecting action against this type of ventricular fibrillation. The hazard of intravenous injection of procaine in man is too great if such large quantities must be used for him.

Bouckaert and Heymans (1931) have observed in dogs (under chloralose) that section of the pneumogastric nerves and denervation of both carotid sinuses prevents the adrenalin syncope during chloroform anesthesia, possibly due to the predominance of the sympathetic system and the hypersecretion of adrenalin after section of these nerves. The predominance of the sympathetic opposes the sharp dilatation of the heart provoked by the hypertension due to the sudden injection of adrenalin, and thus perhaps prevents fibrillation. They refer to the work of Douglas who has reported that a preliminary injection of adrenalin prevents the production of the adrenalin-chloroform syncope.

Since Levy observed the effects of intravenous epinephrine in producing ventricular fibrillation in cats and dogs under chloroform anesthesia, a number of investigations have been carried out to determine the mechanism of it and the means of protection against this type of ventricular fibrillation.

Besides the specific action of epinephrine upon a heart already damaged by chloroform, it has been shown that the abrupt, sharp rise of arterial blood pressure which follows the administration of the epinephrine seems to play a role of importance in the production of this type of fibrillation.

It is known that the hypertensive action of epinephrine can be suppressed or reversed by the previous administration of dioxane derivatives or of yohimbine. Shen (1938), working in Heyman's laboratory, has attempted to abolish the epinephrine-chloroform type of ventricular fibrillation by the previous injection of such substances. Dogs were used. He was successful in preventing fibrillation in all cases, although he has shown (Shen and Simon [1938]) that he could easily produce fibrillation by the technique used. He suggests that sparing the heart from great dilatation accounts for the absence of fibrillation. Peripheral vasodilatation follows the administration of epinephrine after the dioxane derivatives or yohimbine; the intracardiac tension does not rise so high, and dilatation does not occur.

Hermann (1939) finds that many agents (halogen-containing, hydrocarbon series) are capable of producing the adrenalin syncope, once associated only with chloroform.

Agents Used in Combatting the Hypotension of Spinal Anesthesia.—Several agents have been employed to counteract the fall in blood pressure occasionally observed during spinal anesthesia. Epinephrine is not satisfactory, for its effect is transitory. As often used, it merely whips up a failing heart and increases the peripheral resistance for the heart to work against. It may predispose to the development of

cardiac arrhythmias. Benzedrine has a stimulating effect upon the cortical centers, undesirable during spinal anesthesia. Ephedrine has some stimulating action upon the cortical centers (although less than that of benzedrine). Ephedrine may cause tachycardia. Paredrine is a new and promising agent. It does not increase cerebral activity as does benzedrine or ephedrine. All of these agents are to be avoided if cyclopropane has been or is to be used.

The use of paredrine to correct the fall in blood pressure during spinal anesthesia has been described by Altschule and Gilman (1939). This drug has a powerful pressor action due to stimulation of the smooth muscle of the arterial wall. Apparently it has little or no direct effect upon the heart. It is effective when given orally, intramuscularly, or intravenously. Intramuscularly from 10 to 20 mg. are administered; from 5 to 10 mg. are given by vein. If, five minutes after the intramuscular administration of 10 mg., no rise in blood pressure is observed, the same dose may be repeated. Blood pressure will usually be maintained at the desired level for from one-half to two hours.

Hemodynamic Effects of Procaine-Epinephrine Solutions Administered by Different Routes.—

Pickering, Steinmeyer, and Luckhardt (1938) have compared the hemodynamic effects of subcutaneous, submucosal, and subgingival injections of procaine-epinephrine hydrochloride solutions. Thirty-eight dogs were used. Following submucosal injections the arterial pressure rose 10 to 40 mm. Hg. These rises were much greater than those occurring after subcutaneous injection. In the latter case, the greatest rise was 10 mm. Hg. Also, it is to be noted that the pressure returned to normal sooner here than after the submucosal injection. In a second series of experiments the absorption of procaine-epinephrine from several areas within the mouth was observed. The most marked uniform result occurred following injection in the region of the anterior palatine foramen in the soft tissues over the hard palate.

The clinical implications of this study are of interest. Subgingival injections of even very dilute (1:30,000) solutions of epinephrine may and often do cause considerable rises in arterial pressure. If epinephrine, which causes local vasoconstriction, enters the general circulation so readily, so also must procaine, a local vasodilator. The hazard of using these agents in dental procedures, as is so often done without due consideration for the age and size of the patient and without regard for the possible presence of myocardial insufficiency, coronary disease, or hypertension, is obvious.

(To be continued in the July issue. The references will accompany the last part.)

Review of Recent Meetings

REPORT ON THE MEETINGS OF THE AMERICAN SOCIETY FOR EXPERIMENTAL PATHOLOGY, NEW ORLEANS, LA., MARCH 13-16, 1940*

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(From the Division of Experimental Medicine, the Mayo Clinic)

H. P. SMITH, State University of Iowa, Iowa City, represented the society at the joint session of the Federation with an address on the coagulation of the blood. His work in this field has more recently been concerned with prothrombin activity and the relation of vitamin K to this substance.

The first afternoon was devoted to a joint meeting with the American Association of Immunologists in which twelve papers dealing with studies of virus diseases were presented. **John G. Kidd**, Rockefeller Institute for Medical Research, New York, N. Y., demonstrated the effect of extravasated antibody on the antigenicity of extracts of virus-induced rabbit papillomas. Large amounts of rabbit papilloma virus can be rendered completely nonantigenic on neutralization with the antiviral antibody. Virus-induced growths of wild and domestic rabbits contain extravasated antibody as well as the specific virus. The passive transfer of antibody with extracts of the growths may be responsible for resistance to infection by the papilloma virus when such extracts are transferred to normal rabbits. Since the antibody present also renders the virus mixture nonantigenic, the attempted immunization of normal rabbits with extracts of virus-induced papillomas of cottontail rabbits fails to provide evidence as to whether the virus is present in them.

The nature of natural respiratory contagion of tuberculosis was studied quantitatively by **Wm. F. Wells** and **Max B. Lurie**, University of Pennsylvania, Philadelphia, by means of an air centrifuge to determine the number of tubercle bacilli suspended in a given volume of air. The number of bacilli cultured from sample rabbits' lungs corresponded to the number of organisms in the total air breathed by these animals. Rabbits which inhaled more than 1,000 tubercle bacilli died in a period of five or six weeks with massive nodular caseous pneumonia without tuberculosis of the other organs. When less than 100 tubercle bacilli were inhaled by susceptible rabbits, caseous pneumonia with destructive lesions of hematogenous origin in all organs developed. Under the same conditions of exposure, resistant animals developed slowly a progressive ulcerative pulmonary phthisis without involvement of other internal organs; 96 per cent of tubercle bacilli suspended in air were killed by exposure of the air to ultraviolet light for three seconds.

The production of pressor substance by anaerobic autolysis of renal cortex was reported by **Joseph Victor, Alfred Steiner**, and **David M. Weeks**, New York City Hospital and Columbia University. They found that the fluid from thin slices of

*Abstracts of the papers presented at this meeting will appear in the *Archives of Pathology*. In addition to these, many other papers involving experimental pathology were presented in ten other sections of the Federation of American Societies for Experimental Biology which met concurrently.

Received for publication, April 15, 1940.

dog or beef renal cortex after one to three days' incubation in the absence of oxygen increased the systolic blood pressure when injected intravenously into dogs. Similar material autolyzed in oxygen decreased the blood pressure when injected intravenously in dogs. Only minor changes were produced by autolyzed renal medulla. Anaerobic autolysis of cell-free sterile saline extracts of renal cortex produced a pressor substance which was not found with autolyzing extracts of liver, spleen, lung, or heart muscle. This group of authors also reported that experimental renal hypertension was reduced following pexis of the spleen to the ischemic kidney. A collateral circulation was demonstrated between the joined organs and the return of hypertension was observed in the animals that survived subsequent separation of the pexis.

A motion picture demonstration of ataxia in pigs receiving a synthetic diet fed with the intent of producing a condition similar to pernicious anemia was given by **M. M. Wintrobe, J. L. Miller, Jr., H. Lisco,** and **L. R. Kolb,** Johns Hopkins Hospital, Baltimore, Md. Degeneration of the posterior columns of the spinal cord and degeneration of the posterior root ganglions and peripheral nerves occurred. These changes were not influenced by the various vitamin B components, separately or in combination. Liver contained a definitely protective substance.

A study of the pathologic nature of irradiation sickness by **Virgil H. Moon, K. Kornblum,** and **D. R. Morgan,** Jefferson Medical College, Philadelphia, Pa., emphasized the fact that the changes following extensive roentgen treatment were similar to those occurring in shock. **Harry A. Davis,** Louisiana State University, New Orleans, La., found similar lesions in animals following acute dehydration produced by subcutaneous injections of hypertonic saline solutions.

MEETING OF THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS, BOSTON, MASS., JAN. 21-25, 1940

ROBERT C. ROBERTSON, M.D., CHATTANOOGA, TENN.

A dry clinic was presented by the local surgeons. **Albert H. Brewster** showed cases illustrating foot stabilization in spastic cerebral paralysis, emphasizing the improved function in weight-bearing which could be obtained in properly selected cases. **Joseph H. Shortell** presented two cases of giant cell tumor arising in the femoral epiphysis, one occurring in the distal epiphysis, the other in the capital. Both were treated by curettage with good results. **Otto J. Hermann** demonstrated a conservative method of treating fractures of the os calcis in which he emphasized the importance of submalleolar pressure after reduction of the fracture as a method of preventing callus proliferation distal to the malleolus. The spine is always x-rayed in cases of os calcis fracture. **Frank R. Ober** demonstrated results obtained by muscle transplantations and shoulder fusions in anterior poliomyelitis. If the biceps and triceps are of good power, he considers the transplantation of the heads of these muscles to the acromion preferable to arthrodesis.

M. N. Smith-Petersen presented end results of vitallium cup arthroplasty for ankylosis of the hip. He hopes that this cup may be left in place indefinitely and emphasizes the importance of early active motion. The results included cases of bilateral bony ankylosis of arthritic origin and were most encouraging.

Received for publication, April 5, 1940.

Operative and dry clinics were held at Boston City Hospital, Carney Hospital, Children's Hospital, Massachusetts General Hospital, Massachusetts Memorial Hospital, and Robert Breck Brigham Hospital, at which many interesting principles of treatment together with end results were demonstrated.

A **Symposium on the Treatment of Tuberculosis of the Spine** was conducted by **A. Bruce Gill**, Philadelphia, Pa. The subjects presented and discussed were: **Pathology, J. Albert Key**, St. Louis, Mo.; **Pathogenesis and Medical Treatment, Dr. J. Burns Amberson, Jr.**, New York, N. Y.: and **End Results of Treatment, Walker E. Swift, Mather Cleveland**, New York, N. Y.; **Henry W. Meyerding**, Rochester, Minn.; **Fremont A. Chandler**, Chicago, Ill.; **Z. B. Adams**, Boston, Mass.; **Robert I. Harris**, Toronto, Ont.; **Leo Mayer**, New York, N. Y.; and **Paul P. Swett**, Bloomfield, Conn.

The disease is felt to be hematogenous from other foci to bone, with trauma playing a questionable part. The progress is from tubercle formation to coalescence with abscess formation, from which stage the abscess may progress to sinus formation or healing with calcification may occur. Sclerosis occurs with healing. In the advancing stage of the disease the bone plays a passive role. Sequestration is rare. Spinal involvement may be of central, epiphyseal or anterior type, with multiple foci occurring in about 10 per cent of the cases. Abscess formation and paraplegia may occur as complications. The disease may be self-limiting. Cure probably never occurs, but arrest is the desired result. The infection is usually due to the human type and follows inhalation of the bacilli. Deaths following tuberculosis of the spine total 10 per cent of all tuberculous deaths. The incidence is highest from birth to 9 years of age and is much higher in the negro.

In medical treatment rest is of utmost importance. Mental peace and time are essential factors. Surgery is not indicated in the active, disseminating period. Following arrest, trauma may reactivate the disease. Follow-up study should be continued throughout the life of the patient. The purpose of surgery is to eliminate motion and to establish local rest at the site of the disease. The time of fusion should be suited to the individual patient and in general should be performed after the disease becomes quiescent. Surgical treatment is of doubtful value in debilitated patients or in those with other active tuberculous lesions. Following fusion, medical supervision and prolonged rest are important. The usual causes of death, regardless of the type of treatment employed, are meningitis, pulmonary tuberculosis or amyloidosis. Correction of the kyphosis probably delays healing by separation of the diseased vertebral bodies. Opinions differed as to the advantages of operative and conservative forms of treatment. It was generally felt that surgical fusion was the treatment of choice in adults, while varying opinions regarding fusion in children were presented. Arrest is considered to be present when fusion of the diseased vertebral bodies with return of normal bone density as demonstrated on x-ray is obtained, or when normal density of the vertebral bodies adjacent to the diseased areas is established without evidence of advancement of the disease within the vertebral bodies. Persistent sinuses are interpreted as failure of arrest.

The data presented during this symposium will be compiled for further study.

Syphilitic Lesions of Bones and Joints, Edwin D. Weinberg, Baltimore, Md.—The analysis of several hundred cases was presented which showed that the disease was most frequent between 20 and 40 years of age, and that the tibia was the most frequent site of involvement, although any bone may be affected. The disease may simulate many other conditions. The onset may be gradual or sudden. Multiple lesions are often symptomless and may be demonstrated only by x-ray in which increasing calcification with absence of decalcification is usually the

essential finding. Diagnosis is often difficult and may depend upon clinical response to specific treatment. The union of fractures is uninfluenced by syphilis of the bone.

Malignant Joint Tumors (Synoviomata), Dominic A. De Santo, New York, N. Y.; **Robert Tennant** and **Paul D. Rosahn,** New Haven, Conn. Sixteen cases were analyzed. These tumors are malignant and arise in synovial tissues within joints, tendon sheaths, or para-articular bursa. They are frequently overlooked or undiagnosed. Local excision results in recurrence and metastases. Amputation is considered the treatment of choice. Seven cases were treated with x-ray with improvement in one. It is felt that early diagnosis and amputation are necessary to improve present results.

Tuberculosis of the Long Bones of the Extremities, W. B. Carrell and **H. M. Childress,** Dallas, Tex.—This disease is rare in the United States. A group of 74 cases was analyzed. The disease is of chronic character occurring after 20 years of age in about 50 per cent of the cases. Saucerization of the area of involvement followed by primary closure has given most satisfactory results.

Attainment of Good Posture by Use of Natural Reflex Mechanisms, Royal Storrs Haynes, New York, N. Y.—Animal experiments indicate that posture is maintained through cerebral and lumbar centers. Posture in the human being is largely a question of muscle education through habit which is developed most readily in childhood. Corrective exercises and braces are considered to be of slight value.

A Program for the Care of Crippled Children in New York City, Vernon W. Lippard, New York, N. Y.—After an intensive case-finding campaign the incidence of crippled children in New York City was found to be at least 6.4 per 1,000 persons under 21 years of age. Family income was less than $2,000.00 in 75 per cent of the cases. Coordination of existing agencies for care, education, and rehabilitation was recommended. This coordination can best be obtained through a central bureau.

George E. Bennett, Baltimore, Md., chose **Fractures and Dislocations of the Spine** for the President's Address. A historical study from ancient Egypt to the present day was presented in scholarly detail. Extension dates from Hippocrates, while Malgaigne first used hyperextension. The paper will warrant careful study when published.

Treatment of the Cerebral Palsies, Winthrop Phelps, Baltimore, Md.—It is estimated that 150,000 cases of cerebral palsy are present in the United States. Sixty-nine per cent of the cases studied are within normal mental limits, while 72 per cent present mild or moderate degrees of involvement. Peripheral surgery is of no value in athetosis but offers decided benefits when this is not present.

Bone Tumors, Charles F. Geschickter, Baltimore, Md.—Malignancy has not been observed in osteochondroma in patients under 18 years of age, but has been seen in adults. Of 781 cases of primary sarcoma, a five-year cure has been obtained in 13.5 per cent. Early x-ray findings consist of a mottled triangle of increased density. Early amputation is felt to offer the best hope of cure.

Treatment of Osteogenic Sarcoma, Albert B. Ferguson, New York, N. Y.—Four hundred cases in the Registry of Bone Sarcoma of the American College of Surgeons were studied. It was found that the percentage of five-year cures was less when amputation was performed within six months of onset of symptoms than

when amputation was delayed until after this time. Radiation and excision are now recommended, to be followed by amputation after the six-month period has passed.

The Conservative Treatment of Poliomyelitis With Paralysis, Raymond E. Lenhard, Baltimore, Md.—Early splinting was urged to minimize paralysis and deformity. Maximum recovery in strength was present after eighteen months. Beyond this time physiotherapy did not further increase muscle power.

Fat Embolism, Carlo S. Scuderi, Chicago, Ill.—Experimental study indicates that fat droplets are excreted through the tubules of the kidney. Attempts have been made to immunize experimental animals with the hope of producing an immunizing serum.

Surgical Approach in Supracondylar T-Fractures of the Humerus Requiring Open Reduction, George W. Van Gorder, Boston, Mass.—A posterior approach which affords adequate exposure for internal fixation with minimum trauma was found to be preferable in ten patients with irreducible supracondylar T-fractures. Adequate exposure is felt to be essential if proper reduction is to be maintained.

The Treatment of Cavus Feet From a Conservative and Operative Point of View, Albert H. Brewster and **Carroll B. Larson,** Boston, Mass.—The etiology of this progressive condition is not clear. Multiple surgical procedures are frequently necessary. Triple arthrodesis plus transplantation of the long toe extensors to the metatarsal necks was found to be the most successful type of treatment.

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Lambrinudi Operation for Drop Foot, Vernon L. Hart, Minneapolis, Minn.—A historical survey of the operation was presented, together with personal experience with the operation.

Congenital Amputation, Henry H. Kessler, Newark, N. J.—The cineplastic operation is modified by making canals in the stump, utilizing the movement of the entire stump to replace isolated muscle contraction in producing action by the prosthesis.

Amputation at the Knee Joint, S. Perry Rogers, Chicago, Ill.—Amputation through the knee joint with fixation of the patella on the anterior articular surface of the distal end of the femur produces a three-point weight-bearing surface with a bulbous stump permitting earlier weight-bearing and simplification of the prosthesis. Growth of the bone is unimpaired. Results of cases so treated were summarized.

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Restoration of Function in Fractures of the Tibial Plateau Complicated by Injuries of the Semilunar Cartilages, Guy W. Leadbetter and **Frank M. Hand,** Washington, D. C.—Early operation with excision of the injured cartilage, elevation of

the articular cartilage blocked by bone chips, and early motion is advised. Internal fixation is often necessary. Weight-bearing is permitted after three months. X-ray does not disclose the true pathology present. The end results of cases so treated have been far superior to those treated by conservative measures.

The Restoration of Physiologic and Anatomic Function in Old Ununited Fractures of the Femur (Intracapsular), Edward L. Compere and **John Lee**, Chicago, Ill.—Seven cases have been treated by fixation with autogenous tibial grafts plus three threaded wires. No external fixation is employed. Crutches are used after eighteen days. Union was obtained in six of the seven cases so treated. It is felt that reimmobilization is undesirable in the treatment of any fracture.

Slipping of the Upper Femoral Epiphysis, M. Beckett Howorth, Wilkes-Barre, Pa.—One hundred and thirty-two cases were analyzed. One-half were of the endocrine type. Trauma was usually absent and when present was usually trivial. Synovitis of the hip joint, possibly of infectious origin with subsequent circulatory changes involving the epiphyseal plate, was felt to be the etiologic factor. In untreated cases the results were poor. Treatment in the preslipping stage by drilling of the femoral neck with the insertion of slivers of bone is advised. After slipping has occurred open reduction and fixation by nailing is employed. Preoperative traction is of value. Excellent results were reported in 39 of the 40 cases treated by surgical methods. Early diagnosis was urged.

when amputation was delayed until after this time. Radiation and excision are now recommended, to be followed by amputation after the six-month period has passed.

The Conservative Treatment of Poliomyelitis With Paralysis, Raymond E. Lenhard, Baltimore, Md.—Early splinting was urged to minimize paralysis and deformity. Maximum recovery in strength was present after eighteen months. Beyond this time physiotherapy did not further increase muscle power.

Fat Embolism, Carlo S. Scuderi, Chicago, Ill.—Experimental study indicates that fat droplets are excreted through the tubules of the kidney. Attempts have been made to immunize experimental animals with the hope of producing an immunizing serum.

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of surgery is covered in 216 pages, one must admit that the author has done unusually well. The value of this volume would have been enhanced, however, if the author had used more pertinent illustrations and had discussed some of the diseases more fully.

The Diagnosis and Treatment of Diseases of the Esophagus. By Porter P. Vinson. Pp. 224, with 98 illustrations. Springfield, Ill., 1940, Charles C. Thomas, Publisher. $4.

This monograph devoted to diagnosis and treatment of diseases of the esophagus is an exceedingly practical and useful book. The material is presented clearly and concisely and is based on an extensive experience in this field. At the end of each chapter are well-selected bibliographies for readers who wish to study the subjects more extensively. The subject material is well illustrated throughout the book.

An excellent description of symptoms for each of the diseases discussed indicates the value of an adequate history in these cases.

The value and safety of dilatation of strictures and spasms, using a swallowed twisted silk thread as a guide, is clearly demonstrated.

Surgical procedures which may be necessary in the treatment of these cases are outlined briefly, but no attempt is made to present details of operations as found in texts on thoracic surgery.

Careful study of this book by both specialist and general practitioner should reduce errors of diagnosis and treatment of diseases of the esophagus to a minimum.

Everyday Surgery. By Lambert Rogers and A. L. d'Abreu, with an introduction by Professor G. Grey Turner. Pp. 280, with 160 illustrations. William Wood & Company, Baltimore, 1938. $4.75.

G. Grey Turner, in his introduction, states: "It is the purpose of the authors of this book to smooth away difficulties and to focus attention on essentials, though no one must imagine that they are expected to learn the art of surgery from the perusal of its pages, and it is more to be looked upon as a guide in emergency or as a remembrancer in times of stress and trouble." This statement very adequately describes the contents of this book.

As the authors state in the preface, it is a somewhat dogmatic presentation of their own views of everyday surgical practice. Being a presentation of their own views, there are no controversial methods of treatment expressed, and although there are other well-recognized methods of treatment than those they describe, the principles set forth by them are sound surgical principles. As may be ascertained from the title, the book is self-limited, but it takes up all of the more common conditions encountered. It is rather welcome to read a text which is as dogmatic as this one, but, of course, that very fact limits its value, unless one has a fairly wide knowledge of surgery and is thus able to realize that some of the methods of treatment are open to some controversy.

One instance of this is found under the discussion of "General Peritonitis and Paralytic Ileus Following Acute Appendicitis," in which it is stated that the hope of recovery lies in the return of peristalsis, and the intramuscular administration of pituitrin followed by an enema is advocated. The general consensus of opinion, in this country at least, is that the stimulation of peristalsis in a general peritonitis is liable to spread an infection which the host is attempting to localize.

Book Reviews

Caesarean Section. Lower Segment Operation. By C. McIntosh Marshall, F.R.C.S. Cloth. Pp. 230, with 107 illustrations, including 2 plates. Baltimore, 1939, Williams and Wilkins Company. $6.50.

This is a monograph of 230 pages. It is almost entirely devoted to the development, present status, and results of the surgical techniques of cesarean section. With the exception of a report on his own 246 cases, the author presents nothing new. One gathers the impression that the main object of the publication is to acquaint British obstetricians with the advantages of the low cervical section and local anesthesia.

The first portion of the book deals with the history of the development of the operation. It is detailed and well illustrated. The author gives little space to Sänger's work and is more interested in the peculiar anatomical approaches than in the development of the basic principles which established the operation. Harris, in this country, and his early work on the time factor in relation to outcome are not considered. Indeed, a consideration of the development of knowledge which made the operation possible is conspicuously absent. The author gives a long, detailed list of his own operations and among them are very many which leave a doubt whether the preoperative condition of the patient was considered in at all the same light as it would be in this country. In spite of that, his results have been astoundingly good.

Marshall makes a plea for routine cesarean section of the low cervical type for all cases of placenta previa and without other diagnostic procedures than external palpation and history. This will not meet with agreement in this country. A long list of operations were performed for toxemia of pregnancy, but it is not possible to evaluate the indications because of inadequate data. The same may be said of the indications when the sections were performed for cardiac disease.

The form of the book is attractively printed and is graced by excellent illustrations. The index is extraordinarily complete.

Surgical Diagnosis. By Stephen Power. Cloth. Pp. 228, with 51 illustrations and 15 plates. Baltimore, 1939, Williams and Wilkins Company. $4.50.

It is difficult to evaluate this volume on surgical diagnosis. The author states that he has tried to write a practical guide rather than a theoretical treatise, with brevity as the keynote. As a result, this book is not fundamental enough for students and is too brief to be of value as a reference book for practitioners. One is impressed by the undue emphasis upon laboratory procedures rather than physical findings in the diagnosis of disease. The discussions of certain diseases, such as hand infections and intestinal obstruction, are so incomplete that they are vague.

However, students will probably remember the aphorisms and mnemonics, which are well chosen. The method of making a rapid survey of the central nervous system is well worth remembering (pp. 86-87). The chapter concerning intracranial injury is excellent. When one considers that practically the whole field

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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JANUARY—JUNE, 1940

ST. LOUIS
THE C. V. MOSBY COMPANY
1940

There is no attempt to discuss the etiology or pathology of the different conditions to any extent. The operative treatment in many conditions is discussed in some detail for minor procedures and only in principle for more major procedures.

In general, this book makes easy reading for one who wishes to review quickly the common aspects of the more common conditions met in everyday practice. It would probably prove of some value to the general practitioner and to the student who has already finished his course in general surgery. The reading time is about eight hours.

Compendium of Regional Diagnosis in Lesions of the Brain and Spinal Cord. By Robert Bing, translated and edited by Webb Haymaker. Ed. 11. Pp. 292, with 125 illustrations, 27 in color, and 7 plates. St. Louis, 1940, The C. V. Mosby Co. $5.

Three decades have passed since the first publication of Bing's Compendium, now in its eleventh edition and so widely known as to require no detailed description. The design of the work remains unchanged since the first edition (1909), which the author prefaced with the statement: "Its chief task is to give a presentation of a subject generally reputed difficult and complicated, which shall be as clear and simple as the author can make it, while not failing to be accurate and comprehensive, and which shall furnish, even to those who have special knowledge of neurology, an easily and quickly consulted work of reference." In his preface to the present edition Bing remarks that, while the volume has increased in size, in keeping with the enlarging knowledge of localization, he has kept it within reasonable bounds by the inclusion of only those data which can withstand the most critical scrutiny as to soundness and practical value. The translator, granted freedom to amplify the work, has expanded especially the sections on anatomy and function of the bladder and on localization by x-rays.

As a concise, systematic outline of the essentials of functional anatomy of the nervous system and of the principles of localization, the *Compendium* has given and will continue to give a distinctly useful service. Its value, however, would have been enhanced by more exacting attention to phrasing, and there are occasional lapses in factual statements. Above all in a book of this character, condensed as it is and intended particularly as a guide to the elements of localization, the utmost precision is essential. To select examples illustrating this comment, it will be evident that previously uninformed readers are likely to be confused and possibly misled on some points. Page 17: "One should also determine to what extent the tracts are interrupted and the medullary centers destroyed." Page 20: "Tracts descending from the basal ganglia. . . ." [a section heading under which are listed the rubrospinal, tectospinal, and vestibulospinal tracts]. Page 30: "From the clinical standpoint the terms 'general sensibility' and 'sensation' have the following connotations." [As if there were a distinction to be drawn between sensibility and sensation, paralleling the customary separation of the general and special senses]. These are minor faults, and the book doubtless will enjoy the favorable reception warranted by its merit and long history of usefulness.

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Printed in the
United States of America

Press of
The C. V. Mosby Company
St. Louis

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Printed in the
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Press of
The C. V. Mosby Company
St. Louis

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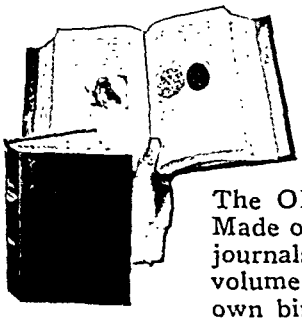
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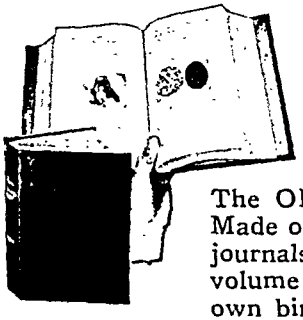
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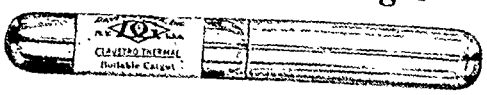
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924	Medium chromic—type C	18″	00 to 3
954	Kal-dermic	20″	000, 00, 0
964	Horsehair	2 x 28″	00
974	White silkworm gut	2 x 14″	00, 0
984	White twisted silk	20″	000, 0, 2
986	Anacap silk	20″	000, 0, 2
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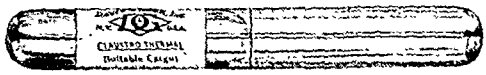
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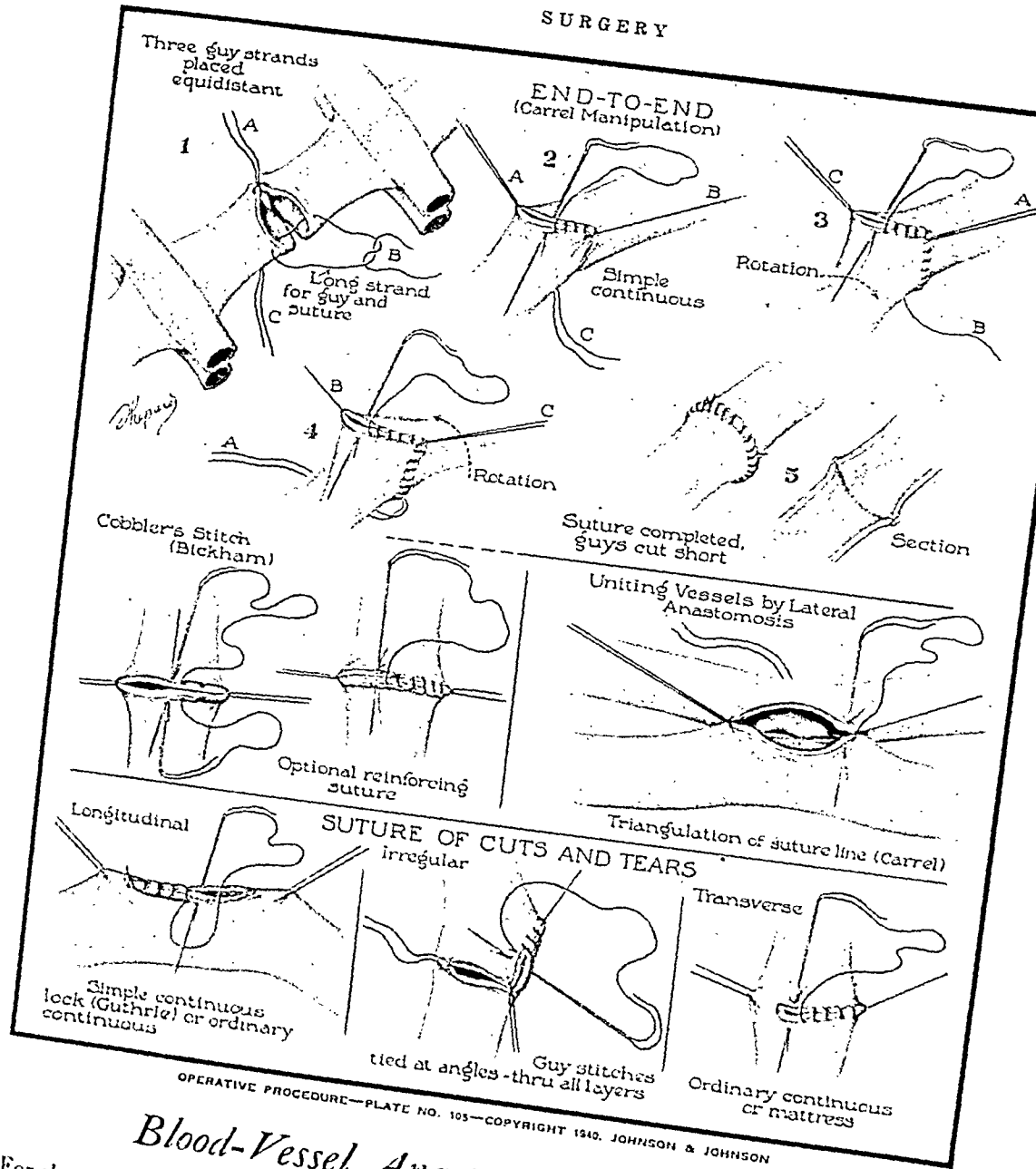
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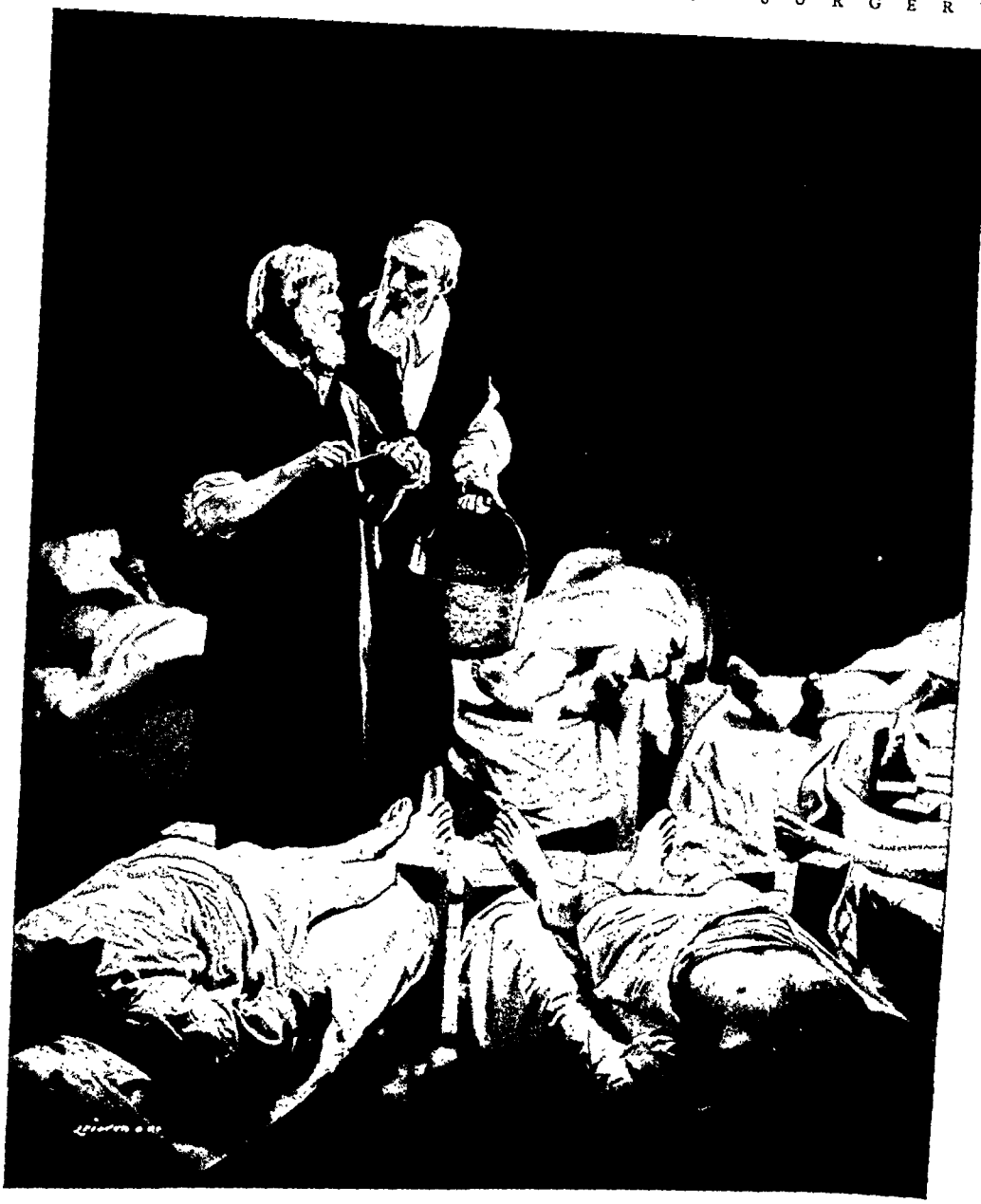
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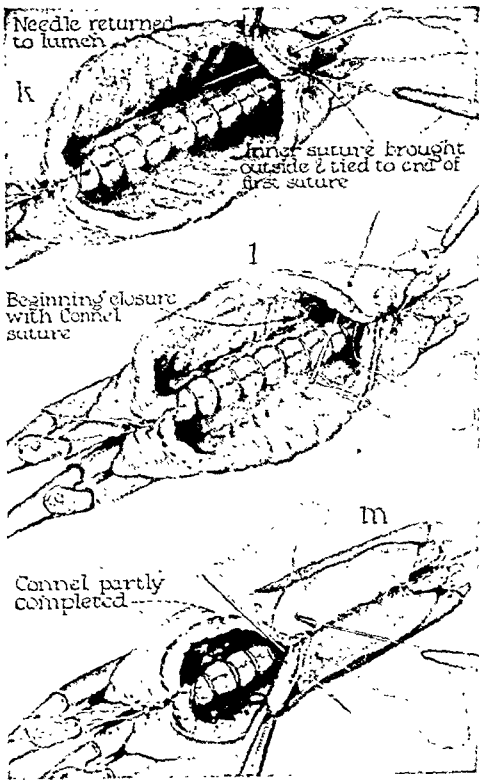
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SURGERY

VOL. 7 MAY, 1940 No. 5

Original Communications

THE RESULTS OF GASTROENTEROSTOMY IN GASTRIC AND DUODENAL ULCERS

REPORT OF 106 CASES FOLLOWED FOR AN AVERAGE OF 7.1 YEARS POSTOPERATIVELY

REYNOLD E. CHURCH, M.D., AND J. WILLIAM HINTON, M.D.
NEW YORK, N. Y.
(From the Bellevue Hospital)

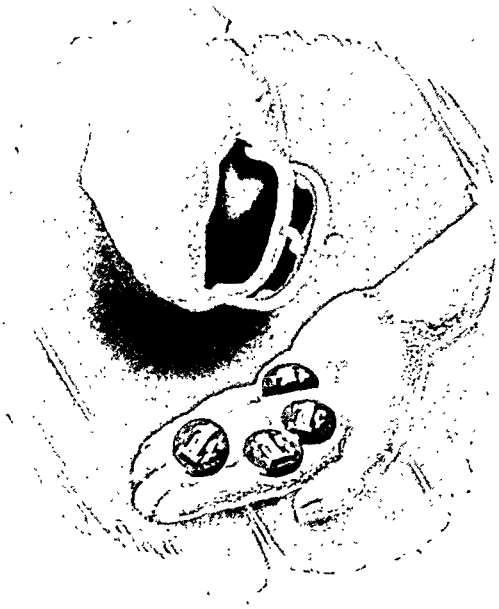
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In this group there were 106 cases of gastroenterostomy, which have been followed for at least one year, and for an average of 7.1 years, postoperatively. These patients made a total of 2,694 visits to the clinic, or an average of 25.4 visits each. No case is reported in this group in which the follow-up period was less than twelve months. Sixteen additional cases of gastroenterostomy, followed in the clinic for less than one year, have not been included in the present study.

We thought in the early years of our clinic that results from gastroenterostomy were going to be satisfactory, but, as time went on, we began to suspect that our results were not similar to those being reported by other clinics. This suspicion resulted in our first study and analysis of results from this type of operation, published in 1933.[1] The present paper is a second analytical study of the gastroenterostomies to see what light can be thrown on the subject by additional cases and a longer period of observation.

If there is any merit in this report it is due (1) to the continuous personal contact between patients and physician which resulted in the recording and study of all complaints, and (2) to the frequency

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of the roentgenologic studies. It is our policy to make roentgenologic examinations on each patient every six months, unless symptoms call for more frequent intervals.

Our personal follow-up method showed that statistics obtained by letter are of questionable value. A patient of ours, for example, reported himself as well (in a letter), but on the records of another hospital it was found that he had been operated upon for a recurrence. It is common knowledge that "failures do not return"; neither do they respond to follow-up letters. It has been our experience that these individuals must be traced to their homes at frequent intervals if accurate data are to be obtained.

Our continuous follow-up (more than twenty-five visits per patient over an average of seven years) was based on the belief that a single observation after a lapse of one or several years is quite misleading. The symptomatology of peptic ulcer is a cyclic phenomenon. Unless there are frequent periods of observation, this periodicity may be lost sight of. Patients seen in a symptom-free interlude have frequently forgotten the discomfort suffered only a few months before. We therefore attempt to follow our patients at intervals of three months. Six months or a year would allow them to fall into periods of remission. The three-month checking period allows us to keep an accurate graphic study of weight, a factor most important in prognosticating recurrences.

Although the results of our analysis are not favorable to gastroenterostomy, it is not our purpose to condemn the operation in favor of some other, such as, for instance, subtotal resection. We wish merely to present the findings and results as we have found them after a fairly extensive study. Our findings in subtotal resection will be evaluated later.

This study may prove of considerable interest because of the large number of factors we have attempted to determine. We not only present our end-results, but we also have broken them down into their component parts, showing the results in different anatomic and symptomatic ulcer types. Our statistics should aid in determining the kind of patient in whom ulcers are most likely to occur, since they are derived from a study of postoperative cases.

Men and women of different nationalities and occupations are represented in the group, and tabulations have therefore been made to show the average ulcer individual in his physical conflict against the disease. The analysis comprises totals, averages, and percentages from 96 males and 10 females, a ratio of 10:1, which bears out the already established conception of marked prevalence in the male (Table I). The average weight in this group of patients was 140 pounds, a finding in agreement with our former observation.[1]

TABLE I

SEX

	NUMBER	PER CENT
Males	96	90.5
Females	10	9.5

The majority of our peptic ulcer patients were between the ages of 20 and 50 years at the time of operation (Table II). The range of ages was from 22 to 69 years, with an average of 38, indicating prevalence in the period of greatest activity. Symptoms had been present before operation for an average of 5.6 years, which indicates that the average age at which ulcer activity had begun was 32.4 years.

TABLE II

AGE AT OPERATION

	NUMBER	PER CENT
20-30 yr.	27	25
30-40 yr.	43	41
40-50 yr.	21	20
50-60 yr.	10	10
60-70 yr.	3	4
Youngest patient	22 yr.	
Oldest patient	69 yr.	
Average age	38 yr.	
Average preoperative duration of symptoms	5.6 yr.	

TABLE III

BIRTHPLACE

	NUMBER	PER CENT
United States	39	37.5
Ireland	17	16.3
Italy	13	12.5
Russia	12	11.5
Germany	6	5.8
Britain	3	2.8
Scotland	3	2.8
Hungary	3	2.8
West Indies	3	2.8
Scandinavia	2	1.7
India	1	1.0
Turkey	1	1.0
Spain	1	1.0

In Table III the nationalities, or to state it more accurately, the birthplaces, of patients are given. These data are not widely applicable, since in different localities immigration may have caused certain groups to predominate. The fairly high number of Irish, Italian, and Russian subjects (13, 13, and 12 per cent respectively) was perhaps to have been anticipated in a study made in New York City.

Many reports have stressed the effects of certain confining occupations tending to produce or aggravate peptic ulcer. We have grouped the occupations in our series as nearly as possible under similar conditions of exposure, confinement, and continuity of duty (Table IV).

TABLE IV

OCCUPATIONS

	NUMBER	PER CENT
Carpenter, painter, mason, machinist, steamfitter, iron worker	14	14.2
Elevator operator, janitor, porter, barber, shipping clerk	14	14.2
Chauffeur, truckman, teamster, automobile mechanic	13	13.2
Laborer, longshoreman	12	12.2
Clerk, ticket agent, cashier, teacher	9	9.2
Fireman, policeman	8	8.2
Operator, cutter, tailor, furrier	7	7.2
Salesman, saleswoman	7	7.2
Cook, waiter	6	6.2
Housewife	6	6.2
Artist, actor	2	2.0

It will be noted that confinement of duty seems to be invariably present in the groups showing the largest percentages of sufferers.

When a study such as this is developed from clinic material, it is imperative to show where the operations were performed, for only in this way can a knowledge of the type and thoroughness of the operative technique be gained. From Table V it will be seen that

TABLE V

PLACE OF OPERATION

	NUMBER	PER CENT
Bellevue Hospital, New York City	64	62.7
Other New York City Hospitals	30	29.5
Total, New York City	94	92.1
Hospital outside New York City	8	7.8
Unknown	4	

92.1 per cent of those patients whose places of operation were known were operated upon in New York City and that 62.7 per cent were operated upon at Bellevue Hospital.

We found in our series that duodenal ulcer was predominant over gastric ulcer in a somewhat higher ration than that usually accepted (Table VI). It is our belief that duodenal ulcers will be reported in

TABLE VI

TYPE OF ULCER

	NUMBER	PER CENT
Duodenal	94	92
Gastric	9	8

higher ratio from other clinics as a better understanding develops of where a so-called pyloric ulcer should be classified.

A custom usually followed in presenting such a paper as this is the recording of preoperative symptoms involving the numbers and percentages of patients suffering from nausea, pain, hematemesis, loss of weight, gastric acidity, etc. We have felt, however, that these general symptoms are elicited or not elicited, depending on the amount of pressure exerted by the examiner. We have found it more important to ask in these cases a question easily answered by a review of the history; i.e., why was the patient subjected to surgical interference (Table VII)? The following causes appear to have been noteworthy:

TABLE VII

REASON FOR OPERATION

	NUMBER	PER CENT
Pain alone	62	59
Perforation	13	12
Pain and obstruction	10	9
Pain and hemorrhage	9	9
Obstruction alone	5	5
Pain, hemorrhage, and obstruction	3	3
Hemorrhage alone	2	2
Obstruction and hemorrhage	1	1

1. *Severe Pain.*—Under this heading comes pain which is not relieved by medication, rest, or diet, and which is without intervals of relief or periods of remission.

2. *Obstruction.*—This is an adequate cause for operation if repeated roentgen examinations show a retention after six hours with severe pain. However, the conscientious use of a dietary regime and antispasmodic drugs in the majority of instances will relieve the obstruction without the necessity of operation, unless severe pain is also present. If the patient suffers severe pain with pyloric obstruction, then surgical intervention is indicated.

3. *Hemorrhage.*—This is an operative indication if repeated in spite of adequate medical regime and if of sufficient quantity to cause anemia. Massive hemorrhage was not a contributing factor in this series.

4. *Acute Perforation.*—Occasionally an indurated ulcer causes obstruction at the pyloric outlet. The performance of gastroenterostomy for an acute perforation is, however, not held in favor at this clinic, as we feel that simple closure is much the better procedure. It carries a lower mortality rate and does not subject the patient to possible postoperative sequelae. (See Table XVI).

5. *Malignant Degeneration.*—This is definitely a threat in all ulcer patients and may be called an indication for surgery. However, there were no cases of malignancy in this series, and, since in our entire group we have seen only a few cases of malignant degeneration, we are not overenthusiastic in using this as a compelling cause for operation.

Also there is a difference of opinion as to the criteria necessary for the diagnosis of marginal or gastrojejunal ulcer. This is understandable, for the term itself is somewhat misleading and the opportunity to observe these findings either at operation or by roentgenography is limited. Such ulcers are best described as occurring about the new stoma after short-circuiting operations. It was found[1] that they occurred at the following sites, in the order given: (1) on the jejunum about one inch distal to the stoma; (2) at the distal wall of the jejunum directly opposite the stoma; (3) on the margin of the stoma at the jejunal side of the anastomosis; and (4) on the stomach wall near the stoma. Roentgen examination presents difficulties. It is hard to find the marginal ulcer in all cases as a niche in the films.

Of the 106 cases, 20, or 18.8 per cent, were found by two or more roentgen examinations or by operation to have gastrojejunal ulcers. In these cases the average time before the ulcer was proved was 4.95 years. In 6 others (5.6 per cent) one roentgen examination and the symptomatology suggested gastrojejunal ulcer. In these the average time before the condition was suggested was 3.5 years. The occurrence of marginal ulcer is presented in Table XIII.

TABLE XIII

MARGINAL ULCER

	NO. OF CASES	NO. OF ULCERS		PER CENT
Gastroenterostomy	106	Proved	20	18.8
		Suggestive	6	5.6
In obstruction	19		3	15.6
In acute perforation	13		3	23.0
In gastric ulcer	9		3	33.3

Hemorrhage presents a perplexing condition. Conservative treatment versus operative interference is still a matter of controversy. However, we accepted as grounds for surgery hemorrhage of sufficient intensity to cause anemia. The results of gastroenterostomy in this type of case are shown in Table XIV. Of the 106 cases, preoperative

TABLE XIV

HEMORRHAGE

In 106 gastroenterostomies, 15 had preoperative hemorrhage (14.1%)
Of 15 cases with preoperative hemorrhage, 7 (46.6%) recurred after an average of 4.43 yr.
Of 91 cases without preoperative hemorrhage, 15 (16.5%) had postoperative hemorrhage after an average of 4.8 yr.
In 106 gastroenterostomies, 23 had postoperative hemorrhage (21.7%) after an average of 4.68 yr.

hemorrhage had occurred in 15, or 14.1 per cent. In these 15 cases, 7, or almost one-half, had postoperative hemorrhages, at an average of 4.43 years after operation. In 91 cases operated upon in the absence

of preoperative hemorrhage, 15, or 16.5 per cent, hemorrhaged postoperatively, after a similar lapse of time. Thus 23 cases of hemorrhage occurred in the group, but the proportion of cases in the group where preoperative bleeding had occurred was far higher.

The end results of gastroenterostomy in obstructed and acutely perforated cases are most illuminating (Tables XV and XVI). In 63 per

TABLE XV

END RESULTS IN 19 CASES OF OBSTRUCTION

	NUMBER	PER CENT
Cured	8	42
Benefited	4	21
Unimproved	7	37
Pain recurred	5	
Pain and marginal ulcer*	2	
Pain, hemorrhage, and marginal ulcer	1	
Pain and hemorrhage	2	
Hemorrhage	1	

*Marginal ulcer following operation occurred in 3 cases, an incidence of 15.6 per cent.

TABLE XVI

END RESULTS IN 13 PERFORATIONS

	NUMBER	PER CENT
Cured	2	15
Benefited	5	39
Unimproved	6	46
Marginal ulcer	3	23
Pain as before	2	15
Massive hemorrhage	1	8

cent of the obstruction group improvement resulted, while 37 per cent were unimproved or were made worse. Among the latter were 15.6 per cent in whom marginal ulcer developed. Gastroenterostomy for acute perforated ulcer is rarely performed in our clinic. In this series of 13 cases, only 54 per cent could be classed as cured, with 46 per cent remaining unimproved or actually made worse by operation. This group showed a 23 per cent incidence of marginal ulcer.

Although gastroenterostomy is now rarely, if ever, performed in gastric ulcer, it was formerly done. The end results following that operation in 9 cases are therefore shown in Table XVII. As was to

TABLE XVII

END RESULTS IN 9 GASTRIC ULCERS

	NUMBER	PER CENT
Cured	2	22
Benefited	2	22
Unimproved	5	56
Marginal ulcer*	2	
Pain and hemorrhage	1	
Marginal ulcer and hemorrhage	1	
Pain as before	1	

*Marginal ulcer occurred in three cases, an incidence of 33.3 per cent.

be expected, the percentage of unimproved cases is high (56 per cent of the cases are classed as failures). There were three marginal ulcers following the 9 operations, an incidence of 33.3 per cent.

SUMMARY

A statistical analysis of 106 gastroenterostomies in peptic ulcer, together with their end results, is presented. This is based on a follow-up study of from 1 to 12 years, with an average of 7.1 years. The results do not produce so favorable a view of this operative procedure as is generally presented by other writers, presumably because of the longer follow-up period adopted.

REFERENCE

1. Church, Reynold E., and Hinton, J. William: A Study of 671 Cases of Peptic Ulcer With Special Emphasis on 114 Postoperated Cases, New York State J. Med. 34: 1934.

CARCINOMA OF THE GALL BLADDER

The Etiological Role of Gallstones

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THE frequent removal of the gall bladder for gallstones and the consequent familiarity of surgeons with this organ has led to a widespread interest in the other diseases to which it is subject. Carcinoma of the gall bladder has received much attention in the medical publications of the past sixty years. Graham[17] and others[13, 23, 31] speak of the condition as being more common than is generally thought. The question as to whether or not gallstones play an etiological role and the vexing problems of prophylaxis and therapy resulting therefrom also make it a subject of general interest. A numerical expression of the risk of developing carcinoma that an individual with gallstones runs would be of great help to the clinician in deciding upon the proper form of treatment of a case in which stones have been discovered but in which symptoms are minimal or absent. It was with this point chiefly in mind that the present study was undertaken. The sources of information have been the files of the Massachusetts General Hospital and the medical literature.

Between January, 1898, and June, 1939, there were admitted to the hospital 84 cases of primary carcinoma of the gall bladder. In 26 of these cases no specimen was taken for pathologic examination, but a definite gross diagnosis of carcinoma of the gall bladder was made at operation. In 58 the diagnosis was proved by pathologic section either at autopsy or at surgical biopsy. All cases of carcinoma of the bile ducts were excluded from this series. Other statistics were gathered from 8,000 consecutive autopsies between 1896 and 1936; from 109,646 consecutive hospital admissions from January, 1925, to June, 1939; and from 1,528 operations for cholelithiasis from January, 1925, to December, 1936.

FREQUENCY

A summary of values for the incidence of carcinoma of the gall bladder in different groups is given in Table I. The first two columns which show that it occurs in from 0.27 to 0.61 per cent of all deaths and in from 2.8 to 5.6 per cent of all cases of carcinoma are the most consistent and most accurate. Graham's figure of 8 to 10 per cent of all cases of carcinoma is not included here because it was derived from

Received for publication, October 31, 1939.

the United States mortality statistics which, as he emphasizes, are not controlled by pathologic examination. According to autopsy statistics at the Massachusetts General Hospital, carcinoma of the pancreas, chosen for comparison because of its familiarity, has an incidence of 1.1 per cent of all deaths. Carcinoma of the gall bladder, being 0.37 per cent, is, then, approximately one-third as common as carcinoma of the pancreas. In European clinics, however, it seems to occur more frequently. Rolleston and McNee[31] found it to be fifth in frequency of all cases of carcinoma connected with the gastrointestinal tract, and Kaufmann's[23] series of over 2,000 autopsies showed it to be three times as common as pancreatic carcinoma. Such differences seem to be explicable only on geographical variations. In the last two columns the figures for its incidence in autopsies on cases with gallstones are somewhat higher than those for its incidence in gall-bladder operations. Without the one high figure of 6.7 per cent of Erdmann, this would be even more striking. It is probable that the operative statistics are the more accurate on this score, because autopsy statistics may be distorted by previous cholecystectomies and possible failure to mention gallstones when they are present. In order to check this information, an analysis was made of the incidence of the two diseases among hospital admissions. From January, 1925, to June, 1939, there were 2,975 cases of cholelithiasis and 40 cases of carcinoma of the gall bladder admitted, an incidence of 1.3 per cent. This period, which is that since the introduction of the Graham test, was chosen because of the probability of greater accuracy of diagnosis with the aid of that procedure. This value is within the range of the incidence of carcinoma of the gall bladder in biliary operations.

From the above evidence it can then be said that carcinoma of the gall bladder is an infrequent disease causing about 0.33 per cent of all deaths and appearing in 1 to 2.5 per cent of all gall-bladder operations.

ETIOLOGICAL ROLE OF GALLSTONES

That gallstones play a strong etiological role in the development of carcinoma of the gall bladder is a belief firmly entrenched in surgical opinion. The fact that this belief is not wholly subscribed to by the internist and general practitioner, and that there have been some recent publications[21, 34] that cast doubt upon it, makes it of interest to weigh both sides of the question. Table II shows a series of values procured from the literature and from the present series which demonstrate the frequency of occurrence of gallstones in carcinoma of the gall bladder. The majority of reports give an incidence of over 60 per cent. There are notably two series which had a lower percentage than this, that of Jankelson and that of Seide and Geller. In the Massachusetts General Hospital series there were only 50 cases in which the presence or absence of stones was definitely mentioned. Of these

TABLE I

THE INCIDENCE OF CARCINOMA OF THE GALL BLADDER

AUTHOR	SOURCE OF MATERIAL	ALL AUTOPSIES	CARCINOMA AUTOPSIES	AUTOPSIES ON GALLSTONES	GALL BLADDER OPERATIONS
Massachusetts General Hospital	8,000 autopsies	0.37%		3.9%	1.96%*
Kaufmann	Unknown no. autopsies		5.6%		
Jankelson	11,400 autopsies	0.27%			
Rolleston	Literature			4-14%	
Illingworth	8,400 autopsies	0.42%	2.8%		1.0-2.5%
Cooper	2,941 autopsies	0.61%			
Hochberg and Kogut	1,074 autopsies	0.6%	4.4%		
Fawcett and Rippmann	592 autopsies			12.3%	
Erdmann	224 operations for cholecystitis				6.7%
Smithies	1,000 cases of gall-bladder disease				2.3%
Deaver	1,000 operations for gallstones				1.6%
W. J. Mayo	3,908 operations on gall bladder				2.16%
Other authors (4, 15, 16)	Reviews of literature and authors' cases			3.3-14.0%	1.0-6.7%
Range		0.27-0.61%	2.8-5.6%	3.3-14.0%	1.0-6.7%

*1,528 operations for cholelithiasis.

44 had stones and 6 had none, an incidence of 88 per cent. It is admittedly difficult in looking over records to know whether to classify cases in which stones were not mentioned as "without stones" or to discard them. In this series the cases, principally those explored surgically, in which stones were not mentioned and the inside of the gall bladder was not visualized were discarded. Those cases in which the gall bladder was opened either as a surgical or autopsy specimen and in which stones were not mentioned are included as "without stones." This seems fair, because, in view of the difficulty with which stones are sometimes palpated through the gall-bladder wall in benign cases, one could expect to be able to feel them in few cases in which the wall is infiltrated with carcinoma. It is frequently difficult to ascertain in the literature what criteria for establishing the presence or absence of stones were used.

TABLE II

INCIDENCES OF GALLSTONES IN CARCINOMA OF THE GALL BLADDER

AUTHOR	NO. OF CASES	INCIDENCE
Massachusetts General Hospital	50	88.0%
Sternberg	115	78.3%
Finsterer	46	93.5%
Judd and Gray	212	64.6%
Rhodes and Greenblatt	23	60.8%
Illingworth	38	81.5%
Jankelson	38	52.6%
Seide and Geller	38	48.5%
Cooper	48	79.0%
Other authors (3, 34, 35)	Undetermined	60-100%

That the occurrence of gallstones in carcinoma of the gall bladder is greater than is found in the population as a whole or even in the selected age group in which carcinoma is most common can be seen by comparing Table II with Table III. The higher figures in Table III (Sternberg and Crump) approach the lower ones (Jankelson and Seide and Geller) in Table II. The general incidence of stones, however, can be seen to be much higher in the cancer group.

There seems little doubt, then, that gallstones are an unusually common accompaniment of carcinoma of the gall bladder. This gives rise to the question as to whether they precede or follow this condition. Aschoff and Bacmeister[2] think on theoretical grounds that the stones either form in the carcinomatous gall bladder or are merely coincidental findings. Even though this were usually the case, it is a common clinical observation that in some cases stones cause symptoms before the tumor develops. Such cases are the ones, rarer to be sure than is generally thought, which give a long history of years of intermittent gallstone colic, longer than it would be possible to harbor an etiological carcinoma and survive. Other evidence against the idea that the carcinoma causes the stones is that of Siegert,[36] who found

TABLE III

INCIDENCE OF GALLSTONES IN POPULATION

AUTHOR	NO. OF CASES	WHOLE POPULATION	OLDER AGE GROUPS
Massachusetts General Hospital	8,000 autopsies	9.65%	
	109,646 admissions	2.6%	
Crump	1,000 autopsies		25%* 50%†
Sternberg	64 cases of carcinoma of bile ducts		54.6%
Shelley and Ross	All malignancies		15.0%
Osler and McRae	Unknown		25.0%‡
Other authors (4 authors quoted by Crump)	Unknown	2.17-10.0%	2.0-25%§
Range		2.17-10.0%	15.0-54.6%

*Under 50 years of age.
†Fifty to 80 years of age.
‡Women over 60 years of age.
§Adults.

that in 13 cases of secondary carcinoma of the gall bladder only 15 cases, or 16 per cent, had stones. Rolleston and McNee[31] say that 7.7 per cent of such cases have stones. This is to be contrasted with the 60 to 100 per cent incidence of stones in cases of primary carcinoma (Table II). Rolleston's criticism that these secondary tumors do not involve the gall-bladder mucosa and so could not be expected to cause stones does not hold in Siegert's series. All his cases had involvement of the mucosa, some with ulceration. If the carcinoma were the cause rather than the result of the stones, the percentage should be much higher; and that even in spite of the fact that patients with secondary carcinoma of the gall bladder have not long to live and form stones. There are other questions, also, that would have to be answered if it were assumed that the stones are caused by the tumor. How would one explain the cases that occasionally occur in which the carcinoma is so small that it could not possibly have disturbed gall-bladder function enough to cause stones? The patient in this series that is living after two and one-half years is one of these. How would one explain the failure of stone formation in the very few cases of carcinoma of the gall bladder which have no stones? The weight of evidence is in favor of the stones forming before the carcinoma.

The considerable amount of animal experimentation which has been done to determine the etiological role of gallstones in carcinoma of the gall bladder has given inconclusive results. Burrows,[5, 6] who has done the largest series of experiments, has failed to produce carcinoma by the insertion of gallstones into the gall bladders of guinea pigs for periods of up to seven years. Thus he has failed to confirm the earlier work of Kazauna[24] and Leitch,[25] who apparently produced definite carcinoma by this means. Because of the equivocal nature of such evidence and because of the doubtful wisdom of comparing such condi-

tions in the experimental guinea pig to those in a human being with cholelithiasis, this work cannot serve the present argument.

From the above discussion it is not possible to state whether gallstones are the direct cause of gall-bladder carcinoma or whether both the stones and tumor are the result of some common irritating or predisposing factor. It can be affirmed, however, from the evidence cited that a gall bladder with stones has a greater chance of developing carcinoma than one without.

PROPHYLACTIC AND THERAPEUTIC CONSIDERATIONS

Carcinoma of the gall bladder does not cause symptoms or signs distinguishable from those of cholelithiasis until it has extended outside that organ. Thus, when it is clinically recognizable as such, it is usually incurable. Most authors have felt so sure of having left tumor tissue behind in all the cases they have operated upon that few attempts at follow-up have been made. Rhodes and Greenblatt[30] report all of a series of 24 cases as dead or dying shortly after operation. If carcinoma limited to the cavity of the gall bladder is found accidentally at or after cholecystectomy for gallstones, the end results may be much better. Thorek[39] reports 5 of 11 such cases living two to ten years after the operation, and in none of the remainder was it definitely known that recurrence took place. Webber[40] and Shelley and Ross[35] each report one case living at six and one-half years. The combining of partial liver resection with cholecystectomy to remove all the tumor has been occasionally attempted. Finsterer[16] reports 1 of his 3 cases thus treated as living at six and one-half years and Hochberg and Kogut[18] also tell of complete removal of the tumor by this means. In the present series attempts were made to follow only those cases observed after Jan. 1, 1925. Of the 40 cases in this period, 35 were operated upon, and of these only 4 left the hospital with any possibility that all the tumor had been removed. One of these was reported as moribund six months later, 1 has not been heard from, and the other 2, cases in which the disease was confined to the gall-bladder mucosa, are living and, as well as can be told by letter, free from disease, twelve years and two and one-third years after operation respectively. No reports of attempts at x-ray or radium therapy have been found. It seems unlikely, however, from the deep-seated nature of the lesion, from analogy with other carcinomas of the gastrointestinal tract, and from its proximity to such organs as the liver and pancreas that this form of treatment would be either effective or well tolerated by the patient.

Since clinically established carcinoma of the gall bladder is incurable, since cholelithiasis is in a definite, if small, percentage of cases (1 to 2.5 per cent, Table I) a premalignant condition, and since the gall bladder is an organ so dispensable and easy to remove, the question

arises as to whether all gall bladders with stones, regardless of symptoms, should not be removed because of the risk of carcinoma alone. This is a policy advocated by some, but since, according to the statistics in Table III, this would involve performing cholecystectomy on 25 to 50 per cent of the female population over 60 years of age, modification of it may well be considered.

An attempt has been made to discover from the recorded clinical findings of our 84 cases any points that might help to indicate which case of gallstones will develop carcinoma and which will not. Table IV shows the duration of symptoms in the 63 cases in which this point could be determined. Of the cases 35, or 55 per cent, had symptoms for six months or less. A few had the "classical" long history of colic or other gall-bladder symptoms lasting over several decades, but the majority did not. At least 5 of the cases in which stones were definitely found had symptoms for less than six months. Of the 84 cases, 52 had in their history pain characteristic of colic and 32 had no colic but digestive symptoms. Although these observations are at odds with those of Magoun and Renshaw[26] who found the average duration of symptoms to be ten to thirty years, they are supported by other observers. Seide and Geller[34] found that 44.5 per cent of their cases had the first symptoms within six months of admission. Fawcett and Rippmann[15] go so far as to say that a history of typical gallstone colic is so rare in carcinoma of the gall bladder that, if a patient presents it, one may say that he will not develop carcinoma. This extreme view is not borne out in the present series of cases, for most of those who had colic gave a typical story of it. It seems logical to conclude, then, from the present data that the case of gallstones without symptoms or the one without a long history or the one without colic is as likely to develop carcinoma as the case with these symptoms.

TABLE IV

DURATION OF SYMPTOMS IN 84 CASES OF CARCINOMA OF THE GALL BLADDER

DURATION	NO. CASES	PERCENTAGE OF THE 63 KNOWN CASES
Less than 1 mo.	17	27.0%
1-6 mo.	18	28.5%
More than 6 mo.	28	44.4%
History inadequate	21	

The number of attacks of colic gives no indication as to which case will develop carcinoma. Since January, 1925, there have been 24 cases of carcinoma of the gall bladder with a history of colic. Of these 12, or 50 per cent, had only one attack; the others, multiple attacks. The number of stones present in the gall bladder gives us no clue as to premalignancy. In the whole group of 84 cases the number of stones was accurately described in only 44. In 40 cases they were multiple,

tions in the experimental guinea pig to those in a human being with cholelithiasis, this work cannot serve the present argument.

From the above discussion it is not possible to state whether gallstones are the direct cause of gall-bladder carcinoma or whether both the stones and tumor are the result of some common irritating or predisposing factor. It can be affirmed, however, from the evidence cited that a gall bladder with stones has a greater chance of developing carcinoma than one without.

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well with those in other series. The predominance of the tumor in females by a ratio of 3:1 and its consistent failure to metastasize by means other than local extension are quite characteristic of the disease.

SUMMARY AND CONCLUSIONS

1. Carcinoma of the gall bladder is not a frequent disease in this locality, occurring in the present series about one-third as commonly as carcinoma of the pancreas.

2. Although carcinoma of the gall bladder may occasionally develop in the absence of gallstones, the great majority of cases are associated with gallstones which precede the development of the tumor.

3. The exact percentage of cases of gallstones that develops carcinoma of the gall bladder is impossible to determine accurately, but probably lies between 1 and 2.5 per cent.

4. No clinical criteria have been established to tell which cases of gallstones will develop carcinoma of the gall bladder.

5. Although carcinoma of the gall bladder is practically incurable once the diagnosis is established clinically, the risk of carcinoma developing in any case of gallstones is so small as not to indicate prophylactic cholecystectomy for that reason alone.

6. The decision as to the advisability of cholecystectomy in cases of gallstones with few or no symptoms should be governed by a consideration of the danger of nonmalignant complications rather than by the risk of carcinoma of the gall bladder.

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and in 4 they were single. This ratio is about what one would expect in cases of cholelithiasis without malignancy and is of no clinical significance.

Since no criterion can be found for selecting the premalignant cases from the others, it remains to weigh the magnitude of the risk of malignancy against the risk of operation. The risk of cancer seems to be 1 to 2.5 per cent (Table I). Simple cholecystectomy for chronic cholecystitis with or without stones in major American surgical clinics today carries a mortality of not greater than 2 per cent (Allen and Wallace, 1.8 per cent; Cheever, 1.12 per cent; Graham, 1.56 per cent; Whipple, 0.78 per cent). If one considers 1 to 2.5 per cent the range of the lowest acceptable incidence of carcinoma of the gall bladder in cases of cholelithiasis and perhaps 5 per cent as the highest (Table I), it seems that in neither case is the operative risk enough lower than the risk of carcinoma to say flatly that cholecystectomy should be performed in all cases of stones for that reason alone. It should be clearly understood, however, that nothing has been said here concerning the far greater risk of the nonmalignant complications of gallstones, notably acute cholecystitis and common duct stone with their possible serious sequelae and greater operative risk. It is not the purpose of this report to attempt to evaluate these dangers which have been so well emphasized by Cheever.[8] It seems to us that the result of the present study is rather to minimize the danger of carcinoma, and thereby to shift more emphasis onto these nonmalignant complications, than to detract from the essentially justifiable concept that all gallstones are harmful.

ADDITIONAL STATISTICAL DATA

In Table V are given, for completeness, further data of interest. The incidences of jaundice, palpable masses, and liver enlargement agree

TABLE V

84 CASES OF CARCINOMA OF THE GALL BLADDER

	NO. OF CASES
Sex	
Male	21
Female	63
Age	
Range	23-83 yr.
Jaundice	
Present	41
Absent	30
Previous gall-bladder operation	8
Mass palpable	39
Liver palpable	39
Distant metastases	0

THE CHOICE OF OPERATIVE METHODS FOR CARCINOMA OF THE RECTUM*

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MODERN surgery for cancer of the rectum and rectosigmoid represents evolution in a most difficult field of surgery, which, beginning with the cauterizations of earliest antiquity, has culminated in the radical excisions of today because of the combined efforts of many enterprising surgeons. It may be said that the proposal of Morgagni early in the eighteenth century, and the first attempt by Faget, in 1739, really mark the initial steps to the modern operations. Before this time, all procedures had been modifications of some posterior type of proctectomy, either a circular amputation or some other variation which left an uncontrollable anus. The majority of these procedures revolved largely around whether or not the removal of the coccyx or a portion of the sacrum and the coccyx was performed. Kocher, in 1876 took away the coccyx and a portion of the sacrum, and nine years later Kraske made his epoch-making presentation before the Fourteenth Congress of German Surgeons. This sacral operation gained popularity and maintained it for a long time through modifications of the brilliant Continental surgeons of that period.

It should be noted that all of these earlier operations could be performed with or without a preliminary colostomy. Allingham and Kelsey were the earlier advocates of a preliminary colostomy, and thereby contributed hugely to the development of operations for rectal resection.

Von Volkmann, in 1887, may be said to have envisioned the so-called combined abdominoperineal operations, but Czerny, in 1883, unintentionally performed the first operation of this type. Miles, in 1907 first employed the modern one-stage combined abdominoperineal procedure which bears his name, an operation which, over the ensuing years, has been established firmly as a fundamentally correct operation for rectal cancer. The trend in recent years in the choice of operation for cancer of the rectum definitely has been toward this one-stage combined abdominoperineal maneuver. This is not to say that a surgeon may discard all other operations from his armamentarium, for multiple maneuvers indubitably promote higher operability curves, lower mortality rates, and more satisfactory end-results. Nevertheless, it seems obvious that more and more surgeons are adopting the radical opera-

*Presented before the International Cancer Congress, Atlantic City, N. J., September 13, 1939.

Received for publication, November 1, 1939.

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which is likewise useful. The glycogen reserve is built up in the liver, the general resistance of the patient is increased, and coincidental debilitating diseases are combated. The cardiac output is measured and balanced as nearly as possible, and, in general, the five to seven days of preparation prior to operation which have now become a routine acceptance appear on the credit side.

Coupled with these measures advances in knowledge of the physiology of the colon, more accurate understanding of the underlying pathology, and more skill in technical details, all have contributed to a progressive elevation of resectability curves without prejudice to mortality figures. More surgeons have familiarized themselves with the details essential to the successful application of more radical procedures, and likewise the profession as a whole has developed a more optimistic outlook in dealing with cases of cancer of the lower gastrointestinal tract. Moreover, it should be recorded that the great urge to save the sphincteric mechanism has been overcome very largely; among surgeons, certainly. This may not be equally true of the general practitioner who first sees the patient, but today, as a result of constant discussion of colostomy, it is being more and more recognized that, when properly manufactured and taken care of, the artificial stoma is not an unbearable companion either from the standpoint of professional activity or social contact. Personal idiosyncrasies influence surgeons to make colostomies in different parts of the abdominal wall, and with equally satisfactory results in most cases. This is a matter to be decided in each individual case separately, the main point being that an artificial stoma must be provided if radical surgery, which means extirpation of gland-bearing tissues to the height of the mesentery of the sigmoid, is to be employed.

The choice of operation probably lies between: (1) combined abdominoperineal or perineoabdominal resection in one or two stages; (2) Mummery's operation of colostomy and posterior resection; and (3) local destruction of the growth with or without segmental resection, and/or preservation of the sphincter muscle. In 1928, I modified Miles' operation for cancer of the rectum, doing it in two stages by dividing the bowel, turning in the lower end and bringing out the proximal loop as an inguinal colostomy. Prior to that, Pauchet, of Paris, had modified the same operation by dividing the bowel, making an inguinal colostomy with the proximal loop, and planting the lower loop in the abdominal wound to be used for irrigation. Daniel Fiske Jones, of Boston, many years before had described a radical operation in two stages which consisted of a loop colostomy, the manufacture of a pelvic diaphragm high up, and a subsequent high resection posteriorly. All of these two-stage operations are useful, unquestionably. Their utility depends upon the answers to two questions: first, do they increase the scope of operability; and second, can one operate upon

tion in one stage in a larger percentage of cases, with a concurrent increase in the operability figures, yet without sacrificing mortality statistics.

This trend represents the influence of many factors, but in the main, it may be said that four considerations have given it the greatest impetus. They are: (1) acceptance of the fact that the principles of radical surgery for cancer elsewhere may reasonably be applied to rectal cancers; (2) acceptance of colostomy as a necessary part of any curative procedure in the majority of instances; (3) acceptance of a longer preliminary preparatory period which insures decompression, aids rehabilitation, and brings the patient to operation in a much improved physical state; and (4) the studious, painstaking work done by Gabriel, Dukes and Bussey, and David and Gilchrist, and others, which has shown without question that more meticulous and detailed search reveals a higher percentage of involved glands in resected specimens than hitherto was suspected. Formerly acceptance of graded operations for cancer of the rectum and rectosigmoid was predicated upon the fact that the majority of these patients, when they presented themselves for operation, were high-grade risks due to obstruction, infection, and devitalization incident to malignancy. To combat the concomitant imbalance of physiologic equilibrium, the gradual institution of a period of treatment prior to operation has become the rule in all surgical clinics.

It would be difficult to overestimate the important influence which this preliminary decompression and rehabilitation has had upon surgery of the colon and rectum for malignancy. Today one would no more think of operating upon an acute obstruction of the lower gastrointestinal tract, save only to decompress it, than one would of resecting a completely obstructed stomach or operating upon a very active hyperthyroidism without preliminary treatment. This has not been true save only in recent years, and recognition of the dictum that resection in the face of obstruction is a highly hazardous procedure is emphatically reflected in operative mortality statistics.

As a matter of fact, most cancers of the left colon and rectosigmoid produce obstruction of some variety in the course of their presence. A large percentage of malignancies in this locality are first seen by the surgeon for relief of symptoms of acute intestinal obstruction. Furthermore, it is not always possible to relieve all the obstruction in a short period of time by preliminary decompression and it is not at all unusual to find at operation telangiectases proximal to the growth and large lymphatics in its immediate vicinity, as well as edema in the colonic mesentery. Prolongation of the preparatory period and repeated efforts to eliminate the vicious products of obstruction are immensely important and, in addition, allow time for rehabilitation,

The trend in my own service parallels a similar choice of operation in that of many of my colleagues, and indicates, I think, that more and more surgeons accept this type of procedure as desirable when it may be applied with a reasonable death rate. Another encouraging and important fact is the changing resectability rate. This rate in the hands of all surgeons experienced in rectal surgery during the past decade has shown a very steady rise. At St. Mark's Hospital in London, Gabriel recently reported a series of cases for the decade, 1921 to 1931, with an operability rate of 54 per cent. This was in sharp contradistinction to a similar group of cases operated upon during the years 1910 to 1920, in which only 41.6 per cent were found to be operable. In my service the operability rate has risen 25 per cent during the last nine years. Between 1925 and 1930 it steadily stayed around 50 per cent; whereas, the series of cases shown in Table I operated upon between 1934 and 1939 shows an operability rate of nearly 75 per cent. This experience of surgeons both on the Continent and in America seems uniform and may be taken as a satisfactory dividend paid in a laudable attempt to apply radical surgery to cancer of the rectum while keeping the mortality rate within reasonable limits.

Unquestionably, there are many cases where the colostomy and posterior resection operation of Mummery is the procedure of choice, a choice justified by end-results and mortality figures. Other operative procedures aimed at preservation of the rectal sphincter elicit little enthusiasm on my part for I am confident that they fail in the vast majority of cases to stand the test of compiled statistical data over a period of time. Local destruction by diathermy or radium or posterior excision with posterior colostomy must be reserved for very special cases selected by a most accurate type of individualization. In the hands of experienced operators the choice of operation most often, I think, will lie between Miles' operation in one stage, or the very similar perineoabdominal resection in one stage, and Mummery's colostomy and posterior resection.

The Combined Operation.—The radical combined abdominoperineal operation may be done either as a single-stage procedure, or as a graded maneuver. One must begin above, making an exploration and continuing the procedure from above downward; or one may make an exploration, as Gabriel and some other surgeons of recent years have advocated, close the incision, turn the patient over and make a pelvic dissection up to the peritoneum from below. The reason for favoring this type of procedure is that there is a reduction of shock if the dissection of the pelvis is made first, although it must be admitted that the abdomen has to be opened twice and there is considerable handling of the patient and moving him around on the operating table, which calls for a great deal of accurate teamwork, not always

the higher risks and do the radical operation in two stages in many instances where the one-stage operation would be too formidable a procedure? This appeared to me to be the case in 1931 when I read an article before the Southern Surgical Association advocating my modification of Miles' operation. Nevertheless, with increasing experience in the use of Miles' operation, better preliminary preparation, and more meticulous technique at operation, it is apparent to me now that there are few, if any, cases which come under my observation in which it is advantageous to employ these two-stage radical operations. That small group of cases upon which one would choose to operate by these two-stage methods had probably best be done by utilizing a colostomy and subsequent posterior resection. The following table of 195 cases operated upon in my private practice during the past five years indicates that the choice of operation definitely has been toward the one-stage procedure, yet without unfavorable influence on either operability curves or mortality statistics.

TABLE I

	CASES	DEATHS	MORTALITY
One-stage combined	100	7	7%
Colostomy and posterior resection	39	3	7.6%
Colostomy alone or with exploration	36	6	16.6%
Exploration alone	10	0	
Two-stage combined	7	0	
Cecostomy (acute obstruction due to cancer)	3	1	
	195	17	
Patients	195		
Operations	241		
Resections	146		
Resectability	74.8%		

It will be noted that the operability rate was three out of four cases. That one must accept borderline cases to accomplish a resectability curve of this height is obvious, but the test of the sound judgment of accepting these cases for resection is reflected in the mortality rate. In this group of 100 cases done by the Miles' combined abdominoperineal type of resection in one stage, there were seven deaths, a mortality rate of 7 per cent. This is the entire mortality rate and eliminates the mortality rate from colostomy alone in the group done by multiple maneuvers. In my own series of 39 cases done by Mummery's type of operation, there were three deaths, a mortality of 7.6 per cent, almost identical with the other procedure. That this mortality is a little higher than routine probably is justified by the fact that for this type of operation the more severe risks were accepted on whom it seemed it would be unwise to attempt so formidable a procedure as the combined abdominoperineal resection.

advisable. In this same connection it might be noted that palliative resection likewise is justifiable and often advantageous if it can be done with a mortality not too prohibitive. For the average case, however, where one may look forward to doing the most radical procedure compatible with a reasonable mortality, the selection will, I believe, in the future more often fall on the combined abdominoperineal resection than any other procedure. Nevertheless, it is scarcely to be expected that so formidable a procedure as the combined resection of the rectum in either one or more stages will ever become routine and safe in the hands of the casual operator, but in this day of specialization when more and more general surgeons have mastered its technique and buttressed their experience with meticulous preoperative preparation and postoperative care, it may be said with considerable emphasis that the trend toward this operation has been definitely advantageous and its applicability distinctly broadened.

This does not mean, of course, that the ultimate in technical perfection has been arrived at in dealing with cancer of the rectum. Certainly, for the surgeon of the future, possibilities of improvement in all fields of surgery remain, and of none is this more true than in surgery of the gastrointestinal tract. Many unsolved problems offer fascinating fields for future research in dealing with growths in this location, but it may be truly said of the present status of surgery for this ailment that enormous progress has been achieved in the past two decades and that end results following application of radical maneuvers are consonant with those reported for cancer elsewhere.

available. Certainly, it seems reasonable that no radical operation should be carried out without an exploration of the liver and the abdominal cavity, but, other things being equal and hepatic metastasis not found, the choice of the operator indicates whether or not the procedure shall be carried out from above or below primarily. Certainly, for growths of the upper rectum and ampulla, one has one's choice, but for those on the peritoneal side of the rectosigmoid juncture, dissection from above downward seems most desirable. There is small difference save only in technique in the radicalness of the two types of procedure, and both are desirable. The personal equation will decide for most operators which method to pursue.

The advantages of the combined operation done in one stage are: (1) it conforms to the principles of radical extirpation of cancer elsewhere, removing the local growth and tissues in the zones of spread; (2) it permits of variations and modifications to be done in either one or two stages; (3) it may be accomplished either as an abdominoperineal or as a perineoabdominal operation; (4) with increasing experience on the part of the surgeon, the operability curve may be broadened and at the same time the hospital mortality remain below 10 per cent; (5) five-year end results from the clinics of the most experienced advocates of the radical combined procedures indicate a higher percentage of five-year cures than for the other types of operation; (6) only one laparotomy is required, so that time and expense are saved for the patient; (7) the blood supply to the growth may be ligated before the pelvic dissection is undertaken; (8) the procedure is applicable to all ampullary and rectosigmoidal cancers; and (9) the mortality differs very slightly from that of perineal excision when operability curves are taken into consideration.

While the ultimate objective of every surgeon dealing with cancer of the rectum is to perform an operation which will be curative, at the same time one should not lose sight of the fact that there are conditions where surgical procedures offer great palliation, despite the fact that metastases deny the individual a chance of living a long period of time. Obstruction with its profound toxemia and anemia calls for by-passing of the fecal current in many instances. I disagree with the views expressed by many surgeons that colostomy should be avoided up to the point of acute intestinal obstruction. Indeed, I think that many times a colostomy long before acute obstruction supervenes is a most helpful and desirable measure to relieve the individual of the discomfort, nausea, etc., which accompanies the profound toxicity of an advanced malignancy. Frequently, by-passing the fecal current relieves the local condition of a great deal of infection and occasionally inoperable growths, fixed and immovable because of inflammation, recede to a point where a resection is deemed

proctoscopic examination. It is rather interesting that the ingested foreign bodies do not necessarily perforate the bowel for considerable lengths of time. In one of the reported cases[21] a soldier was struck in the mouth by a gun butt. A partial plate of artificial teeth which he had in his mouth was swallowed. No symptoms resulted for eighteen years. At this time he suffered an acute attack of abdominal pain which simulated a perforated appendix. At operation a perforation of the cecum was discovered. Partially protruding through the perforation was the missing denture. In one of our cases the perforation of the rectosigmoidal diverticulum by a piece of lobster claw followed two weeks after its ingestion. In this same patient, in a diverticulum adjacent to the perforated one, was an imbedded, encysted nail, which the patient remembered having swallowed some ten years before (Fig. 1).



Fig. 1.—Reveals tremendous pneumoperitoneum with free air under the right leaf of the diaphragm in a case of perforated sigmoid diverticulum.

Perforations by raising intraluminal pressure have been reported following high colonic flushes and compressed air introduced through the anus.[9, 10, 13, 14, 16] Simple enemas, however, may also produce perforations, as is evidenced by one of the cases in this series.

Buie, Bargen, and Rankin[4] state that in their series of 647 cases of chronic ulcerative colitis perforation occurred in 22, or 3.4 per cent.

ACUTE NONMALIGNANT PERFORATIONS OF THE COLON

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PERFORATIONS of the colon from other than malignant lesions into the free peritoneal cavity are fortunately rare in occurrence. Nevertheless, they do happen with sufficient frequency to make their diagnosis important. Isolated cases of perforations of diverticula and perforations by foreign bodies appear in the literature, but most of the texts on surgery, as well as the monographs on emergency surgery, refer to the nontraumatic perforations in passing. Many of the larger series have been reported from the pathologic laboratories.

ETIOLOGY

The acute perforations of the colon may occur from an intraluminal source or from external violence. In this discussion we intend to discuss only the former variety. The most common source of such perforations is from one of the complications of diverticulitis, foreign bodies, or from the acute elevation of intracolonic pressure by enemas or the occasional "compressed air-hose injury." Perforation may occur as a complication of the more severe cases of chronic ulcerative colitis, as well as in the ulcerative stage of tuberculous enterocolitis.

Acute perforation as a complication of colonic diverticula is not included in many of the large series reported. This is probably true because such reports emanate from the large clinics which receive their material from great distances, and therefore do not have the opportunity of seeing as many acute surgical catastrophes as are seen in a large general hospital. In all probability perforation occurs only in the inflamed diverticulum, as a rupture of an intramural abscess, or as the rupture of a peridiverticular abscess. This would not hold true, of course, when one of the other etiologic factors, such as acute elevation of intracolonic pressure, is active in a patient who has colonic diverticula. This happened with surprising frequency in our series, two of the cases being of this type. It may be that the diverticulum is the least resistant point to elevations of intracolonic pressure.

Foreign bodies perforating the colon either may be ingested or may be introduced by the anal route. Into this group one may place one of our cases in which a perforation of the rectosigmoid followed a

Received for publication, October 13, 1939.

there had been a complete anorexia with a definite distaste for food in the last three days. Vomiting in the last two days was preceded by nausea and was small in amount. The past history was negative, with exception of typhoid fever thirty years previously. He had been a carpenter until recent years when he was itinerant, living on a "handout" diet.

Physical examination revealed an acutely ill white man, with pinched face, dry mouth, and seemingly in pain. The temperature was 100.6° rectally; pulse rate, 120; and respirations, 26. The blood pressure was 130/100. The heart and lungs were normal. The abdomen was quite distended, with tympany extending well into the flanks and obliterating the normal liver dullness. There was marked tenderness in the lower abdomen as well as rebound tenderness. No peristaltic



Fig. 3.—Shows barium scattered throughout the pelvis, and on the outside of the distended loops of intestine. This is the film of Case 4 of proctoscopic perforation of the rectum.

sounds were heard in the lower abdomen, but rare tinkling sounds were audible in the upper abdomen. Rectal examination was essentially negative, except for rather marked anal spasm and bilateral tenderness. There was no stool on the examining finger. Urinalysis showed a trace of albumin. The leucocyte count was 14,500. The clinical impression was that the patient had a large bowel obstruction, probably due to a malignant stricture with a fecal obturation. Fluoroscopic examination was advised.

The roentgen examination was carried out by Dr. Max Mass. There appeared to be a large bowel distention of considerable degree. No paralleling of the intestinal loops was observed, but there were many large bowel levels. A peculiar opacity was observed in the area of the sigmoid, about 1½ inches long and

Difficulties in the differential diagnosis arise especially from perforated peptic ulcer, particularly that type in which the gastric juice pour into the pelvis by the route of the right paracolic gutter, fruste perforations of the stomach, acute pancreatitis, perforative appendicitis, perforating Meckel's diverticulitis, mesenteric thrombosis volvulus, strangulated internal hernia, pneumonitis at the pulmonary base, and coronary thrombosis. In perforations of the colon persistent vomiting may be a prominent feature, one which is rare in gastroduodenal perforations. In the latter the gastric gas bubble is usually not visible on fluoroscopy, while in the former it is normally present. Perforative appendicitis is rarely as fulminating as perforative colitis, and the history is usually that of diffuse pain localizing some hours later, then again becoming diffuse. Almost all of these lesions, with the exception of coronary thrombosis and pneumonia, present indications for laparotomy. When the abdomen is open and an exploration reveals a perforated colon, a second incision is made and treatment instituted.

TREATMENT

It is difficult to state what the most advantageous treatment is when the results are so uniformly bad. It can be said that, if there are evidences that the process is localizing, as with a palpable mass, the therapy should be conservative and expectant, awaiting the formation of an abscess. This, unfortunately, is rarely the case, so that active intervention in a poor risk patient must usually be instituted. If, at operation, a foreign body is protruding from the colonic perforation, it must be removed. If possible the perforation should be closed, or the perforated segment exteriorized. Closure of the perforation is often difficult, if not impossible, because of the edema and engorgement of the surrounding tissues. Manipulation tends to increase peritonitis. Rankin, Bargen, and Buie[4] advise the resection of the perforated diverticulum and closure of the bowel if this is possible, with a colostomy above the point of the perforation. Probably the best treatment is the performance of a colostomy proximal to the perforation and with drainage of the site of perforation. This should prevent further leakage. The extravasated feces should be aspirated and in some instances may be gently irrigated with sterile saline solution which is immediately removed by suction. The abdominal wall should always be drained.

CASE REPORTS

CASE 1.—White male, 67 years of age, entered Cook County Hospital complaining of constipation for ten days. This was associated with vomiting for the last two days. During the entire ten days of his illness, he had had some pain in the lower abdomen which was not well localized. This pain was constant and moderately severe, with occasional sharp exacerbations. He had noticed a slow, progressive enlargement of the abdomen during this time. During the ten days

nificant previous history. Anorexia was pronounced. The patient had not had a bowel movement since the onset of the pain, which was constant and severe, not radiating.

Physical examination revealed a young woman acutely ill and in severe pain. Marked tenderness was present in the lower left quadrant with marked rigidity. Rebound tenderness was marked, but there was no abdominal distention. Peristalsic sounds were absent. Obturator and psoas signs were negative. Vaginal examination revealed a normal uterus, *with considerable pain on motion of the uterus, but no adnexal tumor was palpable.* Rectal examination was essentially negative. Vaginal and urethral smears did not reveal any gram-negative diplococci. The rectal temperature was 101.4°; pulse, 110; respiration, 20. The urine was entirely normal. The leucocyte count was 17,000.

The patient was seen by Dr. Peter Rosi, who decided upon *an emergency exploratory laparotomy. A left rectus incision* was made. Free fluid was found in the peritoneal cavity. The uterus and adnexa were normal. The rectosigmoid was explored and an indurated area found. Upon visualization of this area, a foreign body was observed, protruding through a greatly inflamed area of the bowel. This appeared to be a toothpick. *It was removed. It was not deemed* necessary to suture the bowel. The abdomen was closed in layers without drainage. The postoperative course was uneventful, and the patient left the hospital in eleven days without complications.

CASE 3.—A white male, 42 years of age, entered the Cook County Hospital, complaining of severe abdominal pain of twelve hours' duration. The pain had started in the lower abdomen without any definite localization. The onset of the pain was *sudden and excruciatingly severe. He vomited twice, each vomitus being frothy* fluid. He had had no defecation since the onset of the illness. On the day preceding he had had a normal evacuation. Urination had been normal since the onset. The past history was entirely negative. There was no previous history of a peptic ulcer, nor any suggestive symptoms, such as heartburn, etc.

Physical examination revealed *an acutely ill man, lying quietly in bed.* Head, neck, heart, and lungs appeared normal. The abdomen was flat, the legs drawn up. The abdomen was generally tender with boardlike rigidity. Rebound tenderness was marked. On auscultation no peristaltic sounds were audible. Rectal *examination was not significant, but showed a general tenderness. The leucocyte* count was 21,000.

Fluoroscopic examination did not reveal a pneumoperitoneum. The colon appeared moderately distended and there were a few loops of small intestine showing fluid levels. Because of the colonic distention, a barium enema was administered. The barium ran freely through the *sigmoid colon and up the descending* portion. No more was administered as it was thought that any left colonic lesion could be ruled out.

Under a diagnosis of perforated peptic ulcer, a laparotomy was advised. *A right paramedian incision was made under ether anesthesia.* Upon opening the peritoneum, there was no escape of free gas. Instead there was a turbid free fluid. The stomach and duodenum were explored and no ulcer was found. There were no areas of fat necrosis and the gall bladder and pancreas were normal to palpation. *The peritoneal free fluid contained flakes of fibrin and a small amount* of fecal matter. On palpation a mass could be felt in the sigmoid portion of the colon. The transverse colon was then exposed and a transverse colostomy performed. Postoperatively, a blood transfusion was given. Fluids were administered, *but the patient succumbed to the peritonitis two days following operation.* At autopsy a perforated diverticulum of the sigmoid colon was *found with* a generalized fecal peritonitis.

with the general appearance of a nail. This could be freely moved by palpation. A thin barium enema was administered, and this ran freely to the level of the opacity, but would go no further. About one pint of fluid filled the lower segment. There did not appear to be any intraperitoneal leakage. No free air was observed in the peritoneal cavity. Upon further questioning, the patient remembered swallowing a nail about twenty years before. A diagnosis of a large bowel obstruction, probably due to a carcinoma of the rectosigmoid, possibly formed around the foreign body, was made. It was deemed advisable to decompress the bowel by a cecostomy.

The patient was, therefore, prepared with intravenous fluids, and a Levine catheter was introduced. Under spinal anesthesia a typical McBurney incision was made. Upon opening the peritoneum, foul-smelling free fluid escaped, with bits of stool floating in it. The incision was, therefore, closed and a left rectus incision made. Through this incision the rectosigmoid could be observed. A definite perforation, about 0.5 cm. in diameter, was visualized in an area of highly inflamed bowel just above the peritoneal reflection. Through this perforation a foreign body protruded. The body was removed (Fig. 4), and the rent was closed with 3 Lembert sutures. A cigarette drain was placed to the suture site, and another into the pouch of Douglas, and the abdomen closed.

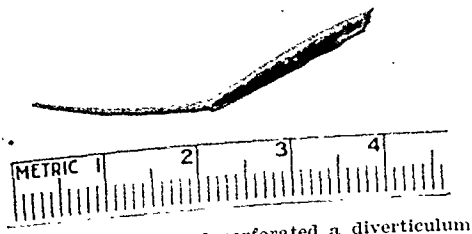


Fig. 4.—Piece of lobster claw which had perforated a diverticulum of the sigmoid in Case 1.

Upon examination, the foreign body did not appear to be a nail, but rather had the appearance of a lobster claw. Upon requestioning the patient he remembered swallowing a lobster claw ten days before the onset of his illness.

The postoperative course of the patient was that of a generalized fecal peritonitis with high fever and an intractable inflammatory ileus. The patient expired on the fourth postoperative day in spite of supportive treatment. Necropsy revealed a generalized peritonitis, with a terminal bronchopneumonia. The perforation was situated in a diverticulum at the rectosigmoid and was closed. Immediately adjacent to this diverticulum was a second diverticulum, in which a nail was found, imbedded in fibrous tissue but not perforating the bowel wall. Several other diverticula were observed, inflamed by contiguity rather than the seat of a diverticulitis.

Summary.—This is a case of a foreign body perforating a diverticulum, with an adjacent foreign body encysted in a diverticulum.

CASE 2.—A white female, aged 29 years, entered the Cook County Hospital complaining of severe pain in the lower left quadrant of the abdomen of eight hours' duration. The onset of the pain was sudden and was constant in its location. The patient was nauseated and had vomited twice. There was no sig-

100/60. Head, neck, and thoracic contents were normal. The abdomen was flat and boardlike in rigidity. There was marked generalized tenderness and rebound tenderness. Rectal and vaginal examinations revealed only tenderness. Peristaltic sounds were absent. The leucocyte count was 14,600. No roentgen study was done.

Under a diagnosis of rupture of the sigmoid, an operation was performed by Dr. P. Shapiro. He found a diverticulum of the upper sigmoid with a definite perforation. The perforation was comparatively simple to close; the abdomen was aspirated and then closed without drainage. The patient expired on the fifth postoperative day with the postoperative course of a diffuse peritonitis.

CASE 6.—A white male patient, 45 years of age, was admitted to the Cook County Hospital with a complaint of pain in the pelvis radiating to the paraumbilical region for eighteen hours, intermittent in character. He had received four tap-water enemas with but little return. They had, however, in no way affected the pain. For the last ten hours the pain had been continuous in the middle of the lower abdomen. The patient had found slight relief in assuming a knee-chest position. There had been no nausea or vomiting. The past history was essentially negative, except that the patient had been under treatment for a peptic ulcer some five years previously. The physical examination was entirely negative except for that of the abdomen. Generalized tenderness, more severe in the lower abdomen, especially in the left lower quadrant, was observed. There was moderate voluntary rigidity. The abdomen was slightly distended and tympanitic. No organs or masses were palpated. Rebound tenderness was moderate. Murphy punch, Rovsing, and obturator signs were negative. Peristaltic sounds were markedly diminished. Rectal examination was entirely negative. The urine was normal, chemically and microscopically. The leucocyte count was 8,600. The temperature was 101.8° rectally; pulse, 70; and respirations, 24. The blood pressure was 140/70.

Fluoroscopic examination revealed a normal chest. There was no free air observed in the peritoneal cavity. A large gas bubble was present in the stomach and a similar bubble in the cecum and ascending colon. No gas pattern was observed in the small intestine. These findings were, therefore, indeterminate. Under a diagnosis of sigmoid diverticulitis, the patient was given conservative treatment with intravenous fluids, Wangensteen suction, etc. Improvement was rapid and all of the patient's symptoms disappeared in three days. The patient was discharged for ambulatory study.

Two days later the patient was readmitted, complaining of severe abdominal pain of eight hours' duration, very similar to that of the previous admission. This time, however, the pain was accompanied by nausea and vomiting. The pain became increasingly severe, and there was a return of the fever. The temperature at this time was 100.8°; pulse, 120; and respiration, 26. The physical examination was the same as on the previous admission, except that there was a suggestion of a mass in the midline of the lower abdomen. Some few hours after admission it appeared that the tenderness was as great, if not greater in the right than in the left lower quadrants. It, therefore, appeared very likely that this patient had a forming appendical abscess. Peristaltic sounds were good at this time.

On the third day of this admission the temperature suddenly rose. The patient's abdomen became exquisitely tender. Within a few hours all peristaltic sounds ceased and the abdomen gradually became distended. The patient vomited so Wangensteen drainage was instituted. Low enemas were without result. Two blood transfusions were administered. A diagnosis of paralytic ileus, probably from a rupture of an appendical abscess, was made. After thirty-six hours the patient expired.

CASE 4.—A male patient, 64 years of age, entered the Cook County Hospital with the complaint of loss of appetite over the last four months, loss of fifteen pounds of weight, epigastric distress, and recurrence of hemorrhoids operated upon five years previously. The history was otherwise essentially negative. Physical examination revealed an emaciated white male, not acutely ill, with a lemon-yellow tint to the skin. In the rest of the physical examination there was found tenderness in the epigastrium and a suggestion of fullness in the region of the cecum. The rectal examination revealed definite hemorrhoidal masses, but no tumor.

With exception of a slight secondary anemia, the blood picture was within limits of normal. The Wassermann and Kahn reactions were normal, but the urea nitrogen was elevated to 20.5 mg. per 100 c.c. of blood. The gastric contents showed no free acid and only 6° of combined acid. Roentgen examinations of the esophagus, stomach, and duodenum were entirely negative. On further observation, however, there appeared to be a filling defect in the region of the sigmoid flexure, and barium enema was advised. A gastroscopic examination was performed by Dr. Rudolf Schindler, who found a thickening and nodulation of the gastric mucosa and one longitudinal ulceration. These findings he believed were compatible with a hypertrophic gastritis, or a lymphosarcoma of the stomach. Repeated stool examinations revealed occult but no gross blood.

Proctoscopic examination was carried out in the usual manner and without any discomfort. On the evening of this day the patient appeared somewhat listless, but not uncomfortable. Castor oil was administered. The pulse and temperature were not significantly altered from the previous course. The night was uneventful and on the following morning the patient went to the x-ray department. A barium enema was administered and after only a few hundred cubic centimeters of the barium entered, it was noted that it appeared on the outside of the bowel rather than in the lumen. It was then noted that there was a large pneumoperitoneum. Films were taken and the patient returned to the ward. The patient now complained of severe diffuse abdominal pain, which was constant and chiefly located in the rectum and lower abdomen. The skin was cold and clammy; the pulse, rapid and weak. The abdomen was distended, diffusely tender but there was no muscular defense. Bowel sounds were entirely absent. Surgical consultation was obtained, and the surgeon deemed the patient in too severe a state of shock to stand an operation at that time. Intravenous fluids were administered, but in spite of supportive treatment the patient expired seven hours later.

Comment.—The time of the perforation in this case is difficult to estimate and the mechanism is not too clear. Most probably the bowel was injured during the proctoscopic examination, and the pressure of the enema completed the perforation.

CASE 5.—A white female, aged 47 years, was admitted to the Cook County Hospital with the complaint of severe abdominal pain over a period of four hours. She stated that, with the exception of an operation for a gynecologic condition and habitual constipation, she had always been perfectly well. On the afternoon of the day of admission she had taken an enema, and, while this was running into the rectum, she suddenly experienced an excruciating pain in the lower left quadrant of the abdomen. The enema tip was immediately withdrawn, and a small part of the enema expelled. The pain continued unabated until admission to the hospital. On physical examination the patient appeared acutely ill, with a temperature of 99.8°; pulse, 120; and respirations, 26. The blood pressure was

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Necropsy revealed that this patient had multiple diverticula throughout the colon. In the sigmoid area there was a 0.5 cm. perforation of a diverticulum, which appeared to be grossly inflamed. There was a generalized feculent peritonitis.

SUMMARY

These cases indicate that acute perforations of the colon occur often enough to warrant consideration of this possibility in all obscure cases of peritonitis, especially in adult males. Previous diagnosis of colon diverticula or a history of mild attacks of peritoneal irritation with or without colon cramps often points to the correct diagnosis. In the early cases the peritonitis can be observed to start about the descending colon; in the late cases the findings are those of diffuse peritonitis and any clue as to the origin must be sought in the history of the onset. This may be as sudden as that of a perforated peptic ulcer. When the onset is accompanied by obstructive symptoms, appendicitis is usually suspected. The longer duration of the obstructive symptoms and their persistence after considerable peritonitis is established should lead one to consider possibilities other than appendicitis. Routine laboratory tests are of little value; x-ray studies, in showing the presence or absence of foreign bodies and pneumoperitoneum and the degree and points of questional distention, are often worth while. The use of a barium enema at times seems rational; yet, when colon perforation is present, it is obviously contraindicated. On more than one occasion we have observed its spill into the peritoneal cavity.

Treatment is determined by the accuracy and detail of diagnosis. The subacute perforation and the acute perforation with limited leakage and localizing peritonitis are best treated conservatively, operative interference being reserved for control of obstruction and drainage of abscesses. Attempts at closure would seem to be justified in acute perforations without evidence of localization, such as postproctoscopic and those due to foreign bodies; even in these instances exteriorization of the damaged segment is often wise. Perforations due to disease do not permit accurate closure, because of the marked inflammatory reaction about the opening. In these, some type of exteriorization is indicated unless mesenteric shortening and adhesions are such that much manipulation is necessary. Drainage to the damaged segment, with or without colostomy above, may then be the method of choice. Colostomy, performed without exploration or any handling of the perforated segment, has resulted in recovery and is probably the procedure of choice, particularly if one is unable to close the perforation. Unfortunately, inaccurate diagnosis often leads to exploration and further peritoneal contamination, which turns a desperate situation into one utterly hopeless.

We wish to express our thanks to Dr. Peter Rosi and Dr. Philip Shapiro for the use of the reports of their cases.

at the same time cause dyspnea, miosis, bradycardia, and lowered blood pressure. All of these effects are manifestations of an equal stimulation throughout the entire parasympathetic division of the autonomic nervous system. Moreover, doses of physostigmine sufficient to stimulate the parasympathetic terminations also act as decided irritants of the spinal cord and the brain (ascending stimulation), bringing about strychnine-like convulsions. Although an efficient stimulant of the intestinal musculature, the simultaneous induction of the other and unwanted effects forces dismissal of physostigmine as a practicable remedy for intestinal atony.

Aeschlimann and Reinert, following an investigation of synthetic physostigmine-like compounds, reported that the dimethylcarbonic ester of 3-hydroxyphenyl-trimethyl-ammonium-methylsulfate exerted a pronounced stimulating influence on the intestinal musculature without affecting other tissues or organs innervated by the parasympathetic system nearly so markedly. Since their report in 1931, a number of investigators have confirmed these findings. The drug has been used clinically for several years for controlling disorders due to parasympathetic depression and more recently for treating myasthenia gravis and is marketed under the name of prostigmin.

The chief use of prostigmin has been in the field of surgery for the correction of intestinal atony with abdominal distention. The prophylactic use of prostigmin, i.e., before the onset of abdominal distention, was first reported by Beck in 1932. He administered 1 c.c. doses of the 1:2,000 solution by subcutaneous injection, which is also the strength and dose employed in the corrective treatment of established distention. Within the past few years, however, 1 c.c. doses of a 1:4,000 solution of prostigmin have been advocated for prophylactic or preventive treatment, reserving the stronger solution (1:2,000) for corrective treatment. More frequent administration of the drug over a period of time (a more suitable schedule for prophylactic treatment) is possible with the 1:4,000 solution and at the same time the total amount of the drug administered is not increased.

Uznanski was one of the first to report on the use of prostigmin prophylactic (the 1:4,000 solution) and his report was soon followed by that of Hendler and a number of other investigators. Harger and Wilkey departed from the customary technique of medication in the prophylactic treatment and recommended that treatment be started immediately at the conclusion of operation and not preoperatively. They reported very satisfactory results from the employment of this method.

Review of the literature and survey and analysis of 131 case records had demonstrated that the incidence of postoperative distention is surprisingly high and that the measures commonly employed achieved far from satisfactory results. The neurogenesis of intestinal atony, the first event in the chain of phenomena leading to abdominal distention and

THE TREATMENT OF POSTOPERATIVE ABDOMINAL DISTENTION WITH PROSTIGMIN

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ABDOMINAL distention in the surgical patient may be defined as the clinical manifestation of intestinal atony of such a degree that the volume and the pressure of the accumulated intestinal contents produce visible distention of the abdominal wall. Intestinal atony (not synonymous with abdominal distention) undoubtedly occurs in all patients following operation, particularly abdominal operations, and may be caused by one or any combination of the following factors: (a) trauma of operation, (b) debilitation due to the disorder requiring operation, and (c) metabolic alterations incidental to surgical anesthesia. In a substantial percentage of surgical cases the intestinal atony is not sufficiently marked to give rise to abdominal distention. However, the absence of distention does not necessarily indicate normal intestinal tone and peristalsis but more probably that the intestinal atony is not severe enough to result in distention. The premise that intestinal atony develops in practically all surgical patients finds support in the fact that urinary bladder atony, which is of identical origin (parasympathetic depression) and caused by identical factors, is an anticipated event, hence the routine order for catheterization p.r.n. postoperatively.

Postoperative abdominal distention is one of the most perplexing problems of the postoperative period. The voluminous literature on its management alone is adequate comment on the dissatisfaction with the effectiveness of the measures commonly employed for the relief or control of this disorder. The incidence of distention, also discussed at length in a voluminous literature, is not well agreed upon.

In view of these circumstances, the case records, selected at random, of 131 surgical patients who had been treated by the usual measures for controlling intestinal and bladder atony, hence postoperative distention and urinary retention, were reviewed and analyzed. In these cases, although the therapy included all methods of treatment described in the literature, such as enemas, insertion of a rectal tube, duodenal siphonage of gas through a nasal catheter, and the administration of analgesics and autonomic drugs, the incidence of distention was found to be surprisingly high.

Since intestinal atony, the basis of postoperative distention, is due to parasympathetic depression, a cholinergic drug seems the rational remedy for postoperative abdominal distention. Physostigmine (eserine) would appear a likely remedy. However, therapeutic doses, i.e., sufficient to increase the tonicity and contractility of the gut musculature,

Received for publication, November 17, 1939.

ing the first six postoperative days is shown in Fig. 2, as well as the percentage it constitutes of the maximum possible distention (extreme or degree 3 distention each of the first six postoperative days). Fig. 3 also pertains to only the distended cases, control or prostigmin-treated, and shows the distribution of the distended cases according to the degree or the severity of the distention, in each operative group and in the total number (all types of operations). The shaded area represents the volume of actual distention in all cases developing this disorder compared to the maximum distention possible (represented by the entire area, shaded and unshaded) in these same cases.

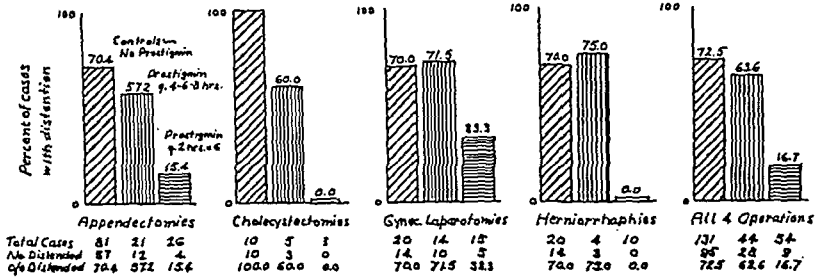


Fig. 1.—Incidence of distention.

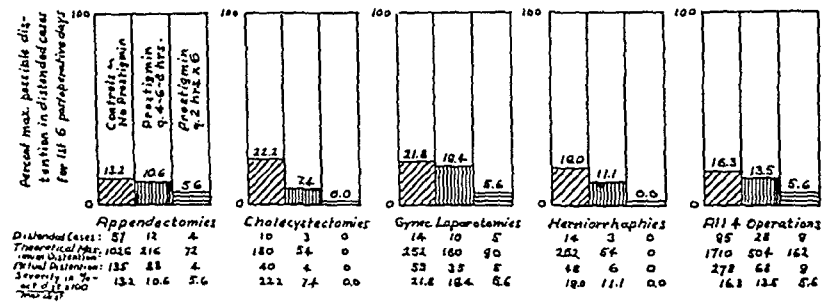


Fig. 2.—Severity of distention.

These charts show that abdominal distention is a common postoperative complication in cases not receiving prostigmin and, moreover, that the distention which develops is much more pronounced than in the prostigmin-treated cases. Although the injection of 1 c.c. of prostigmin prophylactic at intervals of four, six, and eight hours or longer reduced the incidence of distention compared to that in the control cases, the reduction was not as great as desired. It was believed that further reduction could be obtained by adjusting the dosage, and, by the trial-and-error method, the most effective treatment was found to be the injection of 1 c.c. of prostigmin prophylactic every two hours until a total of six doses had been given. The first dose must be injected immediately at the conclusion of operation or as soon as the patient has been returned to his bed. The use of prostigmin in this fashion maintains

the basis of the disorder, indicated that a parasympathetic stimulant or cholinergic drug was the rational remedy. According to published data, prostigmin, in pharmacologic and clinical studies, had the requisite properties: virtually selective parasympathetic stimulation, i.e., marked stimulation of the parasympathetic terminations in the abdominal cavity and much less influence on the other parasympathetic terminations.

The clinical value of prostigmin prophylactic was therefore investigated in ninety-eight cases. The prophylactic schedule reported by others was tried first, but it was found that the administration of the drug at four-hour or longer intervals failed to obtain the desired results and eventually doses were administered at two-hour intervals. In evaluating the drug, the disorder necessitating operation, the type of anesthetic, the general condition of the patient, the operative procedure, and postoperative narcotic medication, all were taken into consideration.

On the basis of the operation, the patients* could be divided into four groups: (1) appendectomies, (2) cholecystectomies, (3) laparotomies for gynecologic disorders, and (4) herniorrhaphies. The same grouping was applicable in the 131 cases whose records were previously analyzed. These cases were therefore used as controls, i.e., cases in which prostigmin was not used. The cases treated with prostigmin prophylactic were further divided into two subgroups: Patients treated with prostigmin at four-, six-, and eight-hour or longer intervals, and patients treated with prostigmin at two-hour intervals. In the latter subgroup the first dose was usually given immediately at the conclusion of operation while the patient was still in surgery, otherwise as soon as he had been returned to his bed.

The objective appraisal of abdominal distention is difficult. The device of using the xiphoid cartilage as a landmark because of its fixed position and ready accessibility (hence, minimal disturbance of the patient) was finally resorted to, and the degree of distention appraised by the relation of the surface of the elevated abdomen to the cartilage. With due regard to the fallacies which creep into a system of numerical recording based on personal appraisal, the degrees of distention were given the following values: 0, no distention; 1, mild distention; 2, moderate distention; 3, extreme distention. In each case the degree of distention on each day was given a single point value, i.e., 0 to 3, and recorded during the period of the first six postoperative days.

For ease in comparison, the data obtained from study of the treated and control cases undergoing the four types of operations were charted. The incidence of distention on a percentage basis in each of the four types of operations is indicated in Fig. 1. Only the control and prostigmin-treated patients developing distention were considered in preparing Fig. 2. The amount of distention which actually occurred dur-

*The majority of the patients comprising the study series were from the surgical wards of the Emergency Hospital, Washington, D. C.; a few were private patients of Dr. Edward A. Cafritz whose constant help and advice made this study possible.

urinary bladder atony, this result could be anticipated. The effect of prostigmin in urinary bladder atony will be the subject of a separate report; however, it may be mentioned that catheterization was required in 15 of 81 appendectomies in which prostigmin was not used; whereas it was necessary in only 4 of 47 appendectomies in which prostigmin was used.

The use of morphine and other opiates pre- and postoperatively in both control and prostigmin-treated cases apparently had no effect on the incidence or severity of the distention. In almost every case morphine sulfate, ¼ to ⅙ gr., was administered preoperatively and followed by one or two such doses postoperatively. Inhalation anesthesia (avertin, ether, ethylene, etc.), spinal anesthesia, or local anesthesia were also found to have no definite bearing on the incidence or severity of distention.

In general the incidence of abdominal distention was higher in women than in men, and higher in negroes than in Caucasians. The incidence of postoperative distention and bladder atony was highest in negresses. The incidence and severity of abdominal distention and urinary bladder atony are directly proportional to the amount of visceral manipulation occurring during the operation.

The contraindications to the use of prostigmin are determined by the answer to the question whether maintenance or stimulation of intestinal tone and peristalsis will or will not extend and aggravate the surgical disorder and its complications. For example, stimulation of intestinal tonicity and peristalsis is certainly contraindicated in intestinal obstruction until the obstruction has been corrected. The use of prostigmin in instances of localized inflammatory lesions anywhere along the gastrointestinal tract should be deferred until the acute stage of the inflammation has been passed. In generalized peritonitis the extent and the virulence of the infection must determine whether maintenance of intestinal tone will spread the infection or whether maintenance of normal intestinal function will improve the tissue vitality and the resistance to spread of the infection.

The benefits derived from the use of prostigmin are not confined to a reduction in the incidence and the severity of abdominal distention. Maintenance of normal or approximately normal intestinal function also benefits the patient through increased rest and freedom from pain. The likelihood of wound infection may also be decreased because of lessened tension on the sutures. Finally, catheterization with its risk of urinary tract infection is less frequently necessary.

Without doubt, there is a connection between surgical shock and postoperative intestinal atony eventuating in abdominal distention. This connection is suggested by the important role of the sympathetic division of the autonomic system which has been discussed at length in the

normal intestinal tone and peristalsis during the postoperative period and reduces the incidence of postoperative abdominal distention to a negligible minimum.

It was also observed that the need for catheterization was materially reduced in the treated patients. In view of the pharmacodynamic qualities of prostigmin and the identical neurogenesis of intestinal atony and

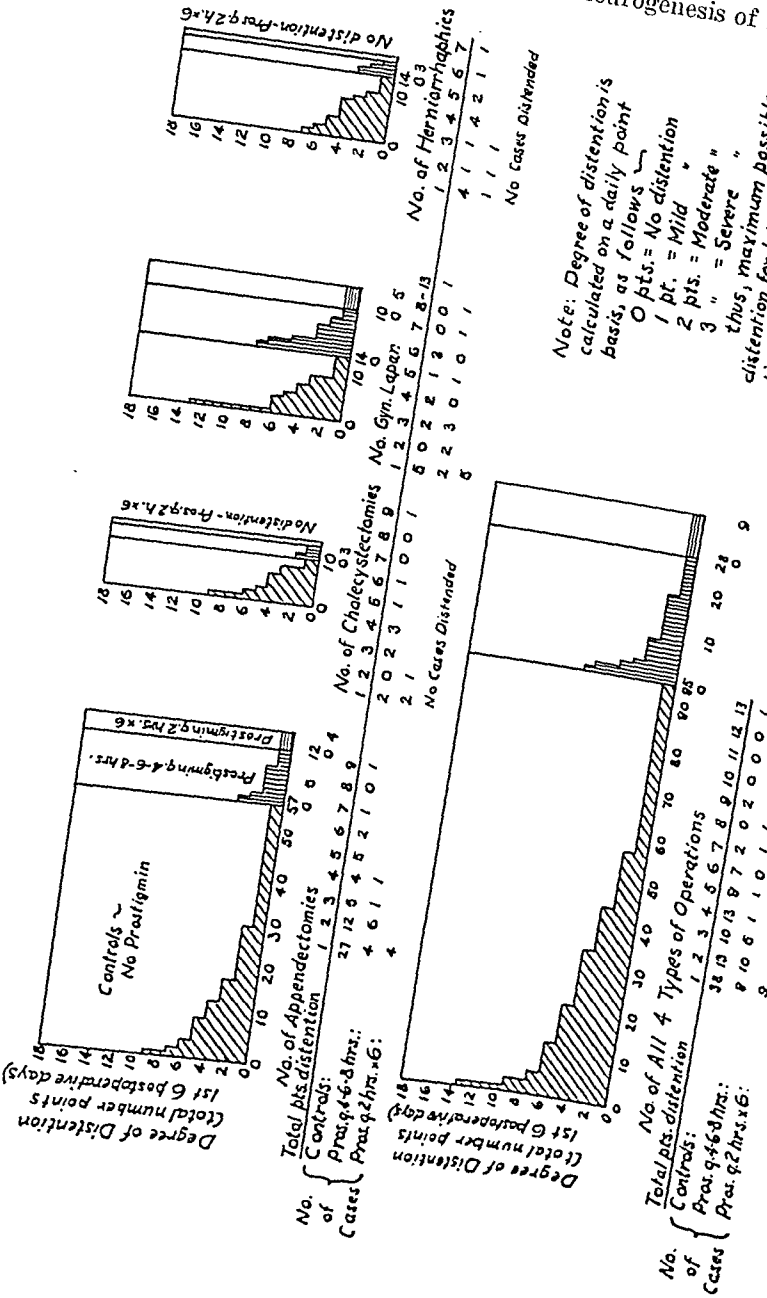


Fig. 3.—Distribution of distended cases according to degree of distention.

obtains optimum results as well. Injections of prostigmin prophylactic at four- to six-hour or longer intervals, even though continued over a period of three to four days, are inadequate treatment. For optimum results the injections should be given at two-hour intervals for six doses.

If abdominal distention should develop after the prophylactic injections, it can be readily controlled by the immediate administration of 1 c.c. of prostigmin regular, 1:2,000 solution, repeated two to three times at one- to two-hour intervals. Fifteen minutes after the first injection, the patient should be given a small glycerine enema; a small rectal tube should be inserted fifteen minutes after each succeeding injection. Few cases fail to respond to this treatment, provided it is instituted at the first sign of distention.

In reviewing the clinical records, it was noted that in cases in which prostigmin was not used maximum distention occurred on the third postoperative day. This circumstance suggests that prevention of postoperative distention may best be obtained by administering the prophylactic course of injections on the second postoperative day.

SUMMARY

The incidence of postoperative distention in two series of surgical cases was investigated and the results in one series obtained from the use of a cholinergic drug for controlling the disorder compared with the results obtained from other methods employed in the other series. One series of 131 patients served as controls, the other series of 98 received prostigmin prophylactic, the 1:4,000 solution. Both series were divided into four groups according to the type of operation: 128 appendectomies, 18 cholecystectomies, 49 gynecologic laparotomies, and 34 herniorrhaphies. The prostigmin-treated series was further divided into two subgroups: (a) 44 patients who received 1 c.c. injections of the drug postoperatively at four-, six-, and eight-hour or longer intervals over a period of three days, and (b) 54 patients who were given 1 c.c. injections of prostigmin prophylactic at two-hour intervals until six doses had been administered, starting immediately at the conclusion of operation.

Of the 128 appendectomies, 81 were control cases, and distention developed in 57, or 70.4 per cent; in 21 prostigmin was injected postoperatively at intervals of four hours or more (Schedule A) and distention developed in 12, or 57.2 per cent; in 26 prostigmin was injected postoperatively at two-hour intervals for six doses (Schedule B) and distention appeared in 4, or 15.4 per cent. Of the 18 cholecystectomies, 10 were control cases and distention developed in 10, or 100 per cent; in 5 prostigmin was administered according to Schedule A and distention appeared in 3, or 60 per cent; in 3 prostigmin was administered according to Schedule B and distention did not develop in any case. Of the 49 gynecologic laparotomies, 20 were control cases and distention

literature pertaining to surgical shock. Reed, in his recent report on surgical shock, states:

"In 1933, Norman Freeman, Am. J. Physiol., 1933, **103**: 185, called attention to the pain factor in the production of shock, and with his experiments proved that when the nerves from the traumatized areas were severed, the shock was greatly reduced. He further showed that the *sympatheticoadrenal system* was quickly affected in shock, causing *vasoconstriction* of all vessels in the body except those of the heart and skeletal muscles.

"In 1925, Cannon and Britton, Ergebn. d. Physiol., 1925, **72**: 283, demonstrated the fact that animals manifesting sham rage secreted an *abnormal amount of adrenalin* into their own blood streams and developed the clinical shock syndrome, reducing the amount of blood in the current circulation with falling blood pressure, and at the same time producing *constriction* of the cutaneous and splanchnic blood vessels, with *dilatation* of those in the skeletal muscles.

"Freeman further demonstrated that the continuous injection of adrenalin into animals over a period of two hours lowered the blood volume as much as 27 per cent and produced the shock syndrome."

In the light of these views, the nervous mechanism in both surgical shock and postoperative abdominal distention is somewhat the same; namely, an autonomic imbalance with a shift in the control of the vegetative processes toward the sympathetic side. In abdominal distention this is brought about by parasympathetic depression and in surgical shock by sympathetic stimulation. In both disorders, however, an autonomic imbalance with a preponderance toward heightened sympathetic activity is the basic derangement.

Preventive treatment of postoperative abdominal distention, therefore, may also be preventive treatment of surgical shock. The use of the cholinergic drug, prostigmin, obviously retards the development of an autonomic imbalance and parasympathetic stimulation effectively counterbalances excessive sympathetic activity.

Although all surgical patients do not develop abdominal distention, the routine employment of a preventive or prophylactic for this disorder is justified until or unless the means are discovered by which the patients that will develop postoperative distention can be differentiated in advance of operation from those that will not. Operations necessitating considerable disturbances of the viscera are inevitably followed by some degree of distention. Prostigmin will do no harm in cases not actually requiring such medication and is decidedly beneficial in those cases that would become distended without its help.

Optimum results can be obtained without administering prostigmin preoperatively. The postoperative administration of a prophylactic course of prostigmin injections not only reduces the number of hypodermic injections, hence annoyance of and expense to the patient, but

obtains optimum results as well. Injections of prostigmin prophylactic at four- to six-hour or longer intervals, even though continued over a period of three to four days, are inadequate treatment. For optimum results the injections should be given at two-hour intervals for six doses.

If abdominal distention should develop after the prophylactic injections, it can be readily controlled by the immediate administration of 1 c.c. of prostigmin regular, 1:2,000 solution, repeated two to three times at one- to two-hour intervals. Fifteen minutes after the first injection, the patient should be given a small glycerine enema; a small rectal tube should be inserted fifteen minutes after each succeeding injection. Few cases fail to respond to this treatment, provided it is instituted at the first sign of distention.

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appeared in 14, or 70 per cent; in 14 prostigmin was administered according to Schedule A and distention appeared in 10, or 71.5 per cent; in 15 prostigmin was administered according to Schedule B and distention developed in 5, or 33.3 per cent. Of the 34 herniorrhaphies, 20 were control cases and distention developed in 14, or 70 per cent; in 4 prostigmin was administered according to Schedule A and distention developed in 3, or 75 per cent; in 10 prostigmin was administered according to Schedule B and distention did not develop in any case.

In the control series (all four types of surgical patients), 72.5 per cent (95 or 131 cases) developed distention. In the prostigmin-treated series, of the group receiving the drug at intervals of four hours or more, 63.6 per cent (28 of 44 cases) developed distention; of the group receiving prostigmin at two-hour intervals for a total of six doses, 16.7 per cent (9 of 54 cases) developed distention.

CONCLUSIONS

1. More or less marked postoperative abdominal distention develops in the majority of surgical patients.

2. Intestinal atony, the basis of postoperative abdominal distention, is caused by depression of the parasympathetic division of the autonomic nervous system.

3. Trauma during operation, debilitation caused by the disorder necessitating operation, and the alteration in the metabolic processes incidental to surgical anesthesia are important factors in depression of the parasympathetic system.

4. Failure to obtain satisfactory relief or control of postoperative abdominal distention with the measures commonly employed is probably due to the fact that they have no effect on the parasympathetic system.

5. Prostigmin, a parasympathetic stimulant or cholinergic drug, was selected for the treatment of postoperative abdominal distention because in the dosage required it effectively stimulates the parasympathetic terminations in the abdominal cavity and has little or no influence upon the parasympathetic terminations elsewhere in the body of clinical importance in the problem of abdominal distention.

6. Since there is no means of differentiating the surgical cases in which abdominal distention will develop from those in which it will not, the prophylactic or preventive use of a cholinergic drug is justifiable and preferable to its corrective use; i.e., withholding the drug until abdominal distention becomes manifest. Patients who would not require the use of a cholinergic drug are not harmed by prophylactic treatment with prostigmin and postoperative abdominal distention is more easily prevented than treated.

7. The incidence and severity of postoperative abdominal distention was reduced in cases in which 1 c.c. of prostigmin methylsulfate 1:4,000

solution (prostigmin prophylactic) was injected subcutaneously at intervals of four, six, and eight hours or more over a period of the first three postoperative days.

8. Adjustment in the dosage schedule for the prophylactic use of prostigmin markedly reduced the incidence and severity of postoperative abdominal distention, compared to these same factors in the control cases and in the cases receiving prostigmin prophylactic at intervals of four, six, and eight hours or more.

9. The most effective technique for the use of prostigmin prophylactic was found to be the subcutaneous injection of 1 c.c. of the 1:4,000 solution at two-hour intervals until a total of six doses have been given.

10. The use of prostigmin prophylactic, 1:4,000 solution, is indicated in all surgical cases except those in which there is intestinal obstruction or an extensive and virulent infection of the peritoneal cavity.

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EFFECT OF COLCHICINE ON HUMAN CARCINOMA

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INVESTIGATIONS of the effect of colchicine as a mitotic poison began with the observation of Amoroso,[1] who noted that in patients who had gout and carcinoma and were treated with colchicine and irradiation simultaneously the tumors regressed more rapidly than usual. After this observation, Ludford[2] found that colchicine added to tissue cultures in dilutions of 1:500,000 to 1:100,000,000 caused an increase in the number of mitotic figures, which resulted primarily from accumulation of arrested mitosis rather than from stimulation of mitosis. He found that in vivo the most extensive accumulations of mitosis occurred in the crypts of the small intestine and in rapidly growing tumors. Such accumulations were also numerous in bone marrow, lymphoid tissue, and hair follicles. He observed that with small doses mitotic recovery was rapid; with larger doses the arrest of mitosis persisted longer; and, if the next injection was made before all the cells arrested in mitosis had been able to complete division, the action was cumulative, cell destruction followed, and, if the action was prolonged, the animal died. His explanation of the effect is as follows: "One of the chief causes of this type of abnormality would appear to be the alteration in the colloidal state of the chromosomes so that the split halves of each chromosome stick together when they would normally separate. This may result in a considerable increase in the time required for separation of the split halves of the chromosomes. Some split chromosomes fail to separate altogether and do not become incorporated in either of the daughter nuclei but form minute accessory nuclei. Others pass undivided into one or other nucleus and result in abnormal chromosome numbers." The last phenomenon has been applied to the hybridization of plants and is used to produce new plants of abnormal chromosome numbers.[3]

Lits, Kirschbaum, and Strong[4] have reviewed the literature concerning the effect of colchicine on animal tumors. They found temporary inhibition of a lymphoid tumor in a mouse. A few investigators have obtained beneficial effects and even cures in cases of animal tumors; others have found little, if any, benefit. Oughterson and his co-workers[5] reported that, of fifteen patients with carcinoma to whom colchicine was given, eleven showed definite arrest of mitosis in metaphase as compared to control biopsies.

If colchicine stops division of cells in metaphase, such an effect would appear to be useful in the treatment of malignancies by irradiation. If irradiation is more destructive to dividing cells, and if the division

Received for publication, November 9, 1939.

of cells could be even temporarily stopped by colchicine poisoning, the effect of the radiation might be increased. Ludford[2] has shown that the more rapidly growing cells are more susceptible to colchicine poisoning. On this basis we decided to try the combined effect of irradiation and colchicine on human carcinoma. We did not have much information concerning the effect of the drug alone on human carcinoma; therefore, we planned first to determine its effect by administration in toxic doses to patients with inoperable carcinoma. We obtained some surprising results, which are the subject of this paper.

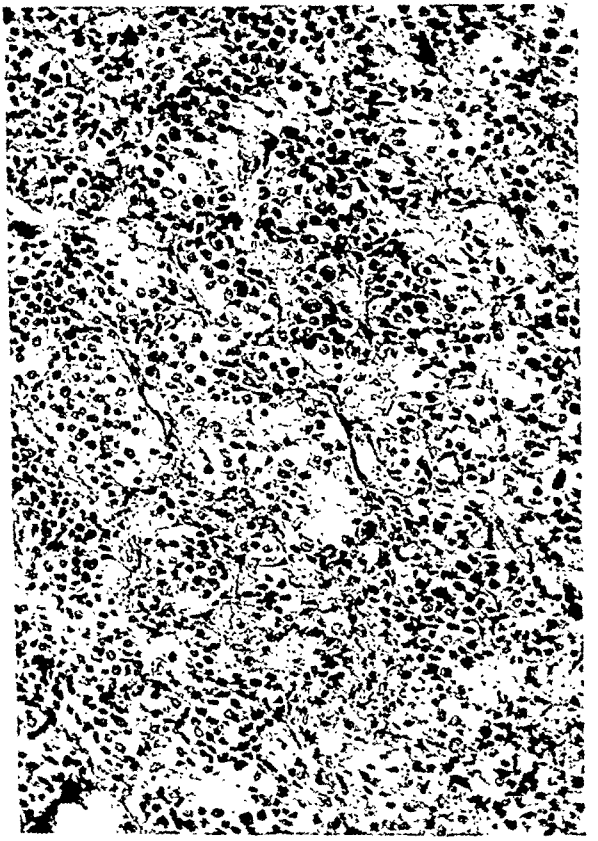


Fig. 1.—(Case 1.) Photomicrograph showing section of adenomedullary carcinoma of the breast before treatment.

REPORT OF CASES

CASE 1.—L. W., a 57-year-old white woman, was admitted to the hospital on Feb. 2, 1939, with a diagnosis of inoperable ulcerating adenocarcinoma of the right breast with axillary metastases. In February, 1938, she noticed a lump about the size of a hazelnut in the right breast. In about four months it had grown and ulcerated through the skin for an area about 4 cm. in diameter. At the same time a lump appeared in the axilla. The mass in the breast and that in the axilla continued to grow, and with the increase in growth she developed increasing pain over the shoulder, down the arm, and into the fingers. In January, 1939, the

entire arm began to swell. She lost only 8 4/5 pounds (4 kg.) in weight, and her general condition remained good.

On admission, the right breast contained a large carcinomatous mass 9 cm. in depth. This was continuous with a large mass of fused metastatic glands involving the entire axilla and subpectoral region. The whole mass was firmly fixed to the chest wall, as well as to the skin. Because of the size of the axillary mass, the arm could not be adducted to the side, and because of its fixation could not be abducted beyond the horizontal level. Laterally and above the nipple was a typical fungating carcinomatous ulcer measuring 3 by 7 cm. The nipple was not visible, being buried in the mass. The nipple area was surrounded by a narrow weeping ulcerating surface. A roentgenogram of the chest revealed no pulmonary metastases.



Fig. 2.—(Case 1.) Biopsy section from a contiguous area after injection of a total of 7 mg. of colchicine in four days, showing destruction of all tissue elements, with cytolysis and pyknosis of nuclei, and degeneration of the stroma as well as the tumor cells.

On Feb. 3, 1939, a biopsy showed an adenomedullary carcinoma of the breast (Fig. 1). On Feb. 6, 1 mg. of colchicine was given intramuscularly (1 c.c. of a solution containing 1 mg. per cubic centimeter). This and all following injections were given intramuscularly, into either the deltoid or gluteal muscles. No injections were given into or near the tumor. All injections produced moderate pain at the time of injection, followed by soreness lasting twenty-four hours.

On Feb. 7, 2 mg. of colchicine was given. There was no ill effect except that the pain in the region of the shoulder was increased.

On Feb. 9, 4 *mg.* of colchicine was given. A biopsy specimen taken from an area contiguous to the first showed marked destruction of all tissue elements, with cytolysis and pyknosis of nuclei (Fig. 2). The *stroma showed necrosis*, with disappearance of cell structure. The reaction was purely degenerative, without evidence of inflammatory reaction or attempt at repair.

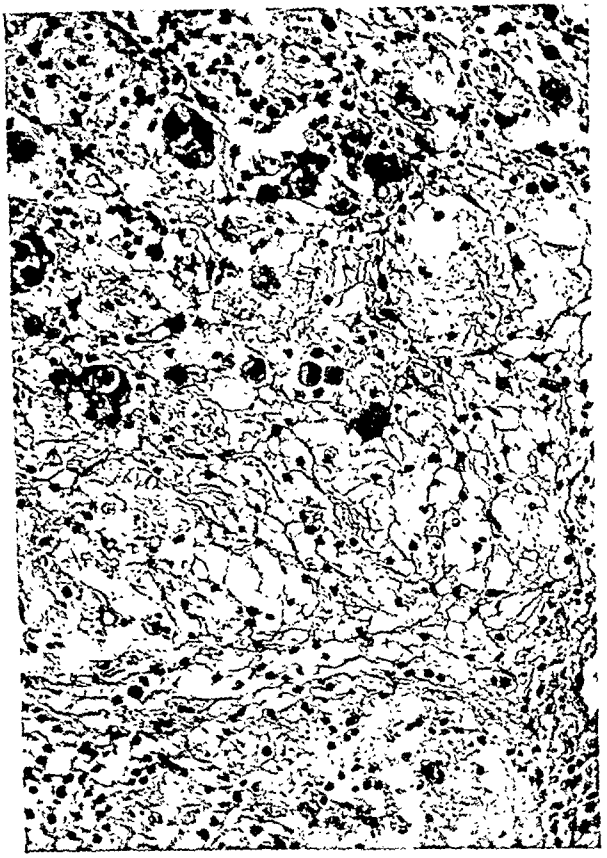


Fig. 3.—(Case 1.) Biopsy section after injection of a total of 21 mg. of colchicine in eleven days, showing further degeneration. The tumor cells show bizarre atypical forms. There is beginning round-cell infiltration into the remaining reticular structure.

On Feb. 10, 7 mg. of colchicine was given. Twelve hours after this dose, the temperature rose to 101° F. and the pulse rate to 120. The patient was nauseated, and vomited several times. Vomiting continued during the night, and in the morning 1,000 c.c. of 10 per cent dextrose solution was given intravenously. On Feb. 12, she was still ill; the temperature was 100.8° F. Another 1,000 c.c. of dextrose solution was given intravenously. The next day she was still nauseated and vomited occasionally. On Feb. 14, the leucocyte count was 4,000 per cubic millimeter.

On February 15, 7 mg. of colchicine was given. The leucocyte count was 1,200 later in the day. The next day the patient was nauseated and took nothing by mouth. There was marked prostration. She was given 3,000 c.c. of fluids intravenously and 500 c.c. of citrated blood. The leucocyte count was 1,100.

On Feb. 17, it seemed that the large ulcerating area had increased in size and exuded a more watery discharge in greater quantity. The surface had changed from bright red to dull gray. Another biopsy specimen was taken, which

showed the degenerative process carried still further, with hyalinization and absorption of the stroma and also of the tumor cells (Fig. 3). The nuclei of the tumor cells were bizarre and atypical. There was beginning small round-cell infiltration into the remaining reticular structure. An occasional mitotic figure in metaphase could be seen.



Fig. 1.—(Case 1.) Appearance of breast tumor seventeen days after beginning of treatment, during which time 21 mg. of colchicine was administered. Sloughing of a part of the tumor as a gangrenous mass occurred. The tumor has become reduced in size, although there is still a large mass in the axilla. Note the skin metastases; these ultimately disappeared, leaving only a pigmented area in the skin. With recurrence each pigmented area again formed a hard nodular mass.

On Feb. 21, 300 roentgen units were given over the breast, with a 15 by 20 cm. portal, 200 kv., and a half-value layer of 0.75 mm. copper. The leucocyte count was 8,500.

On Feb. 23, the large ulcerating area was definitely necrotic for 5 by 6 cm. (Fig. 4). There was a sharp line of demarcation between the sloughing area and the surrounding mass. Later this area was removed en masse, leaving a crater 4 cm. deep.

On Feb. 24, 350 roentgen units were given to the right supraclavicular region, with a 10 by 10 cm. portal.

On Feb. 26, the hair on the scalp suddenly began to fall out in large handfuls, and in four days the patient was almost completely bald. The tumor in the breast and that in the axilla began to shrink with rather startling rapidity. The pain in the region of the carcinoma, which had required daily use of codeine for relief, disappeared.

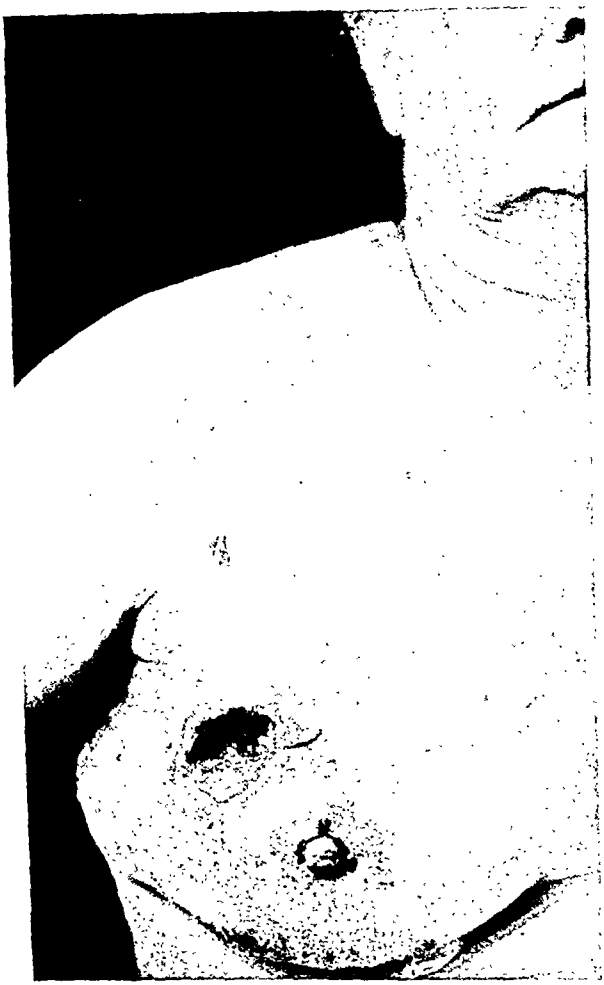


Fig. 5.—(Case 1.) Appearance forty-two days after beginning of treatment. The crater following sloughing of the tumor has begun to epithelialize. The skin metastases, formerly small hard lumps, now appear only as smooth discolored areas. The axillary mass is much smaller.

On Feb. 28, 2 mg. of colchicine was given.

By March 8, the entire mass had shrunk to about one-third its original size. Both the breast tumor and the axillary mass were now movable. The arm could be abducted easily.

On March 10, 2 mg. of colchicine was again given. On March 20, the primary tumor and the mass in the axilla were much smaller (*Fig. 5*).

On March 27, 4 mg. of colchicine was given. In the past two weeks there had been little change in the size of the tumor. The ulcerating area was contracting; the epithelium was growing in from all sides until it was now about one-half its

showed the degenerative process carried still further, with hyalinization and absorption of the stroma and also of the tumor cells (Fig. 3). The nuclei of the tumor cells were bizarre and atypical. There was beginning small round-cell infiltration into the remaining reticular structure. An occasional mitotic figure in metaphase could be seen.

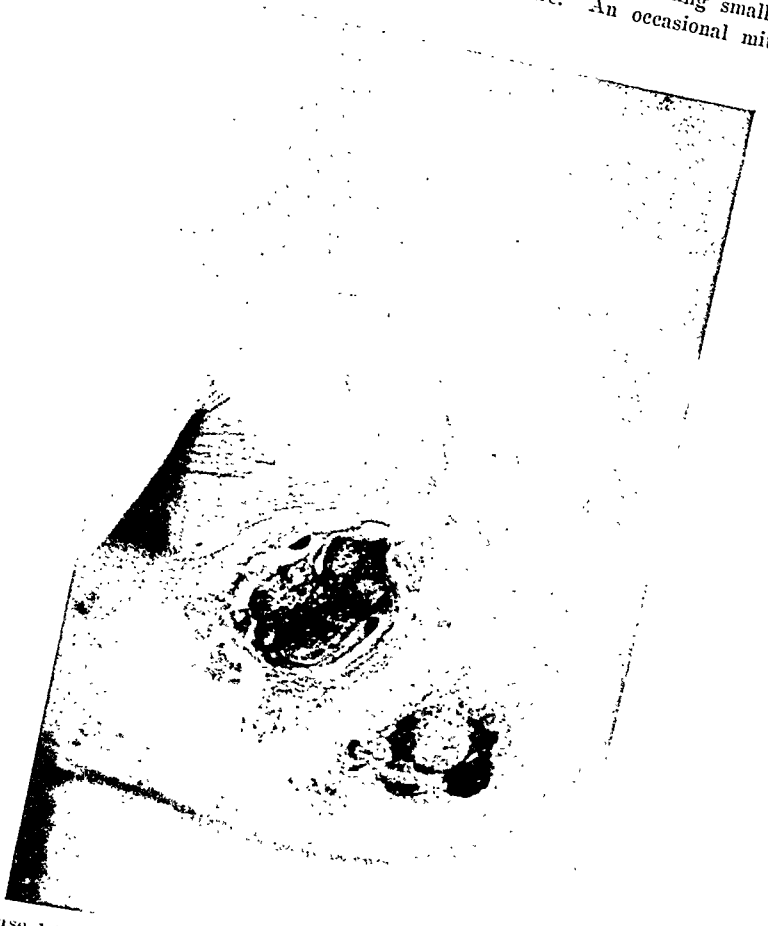


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On Feb. 21, 300 roentgen units were given over the breast, with a 15 by 20 cm. portal, 200 kv., and a half-value layer of 0.75 mm. copper. The leucocyte count was 8,500.

On Feb. 23, the large ulcerating area was definitely necrotic for 5 by 6 cm. (Fig. 4). There was a sharp line of demarcation between the sloughing area and the surrounding mass. Later this area was removed en masse, leaving a crater 4 cm. deep.

On Feb. 24, 350 roentgen units were given to the right supraclavicular region, with a 10 by 10 cm. portal.

Colchicine was administered by deep intramuscular injections in the following dosages: 2 mg. on Feb. 24, 1939; 4 mg. on Feb. 26; and 6 mg. on Feb. 27. After the last injection the patient became nauseated and developed diarrhea, severe prostration, and, later, vomiting. The temperature rose to 101.5° F.

On Feb. 28, the leucocyte count, which had been 10,600 per cubic millimeter, dropped to 6,800. The differential count was as follows: polymorphonuclear neutrophiles, 27 per cent; stab forms, 50 per cent; lymphocytes, 19 per cent; monocytes, 1 per cent; eosinophiles, 3 per cent.

Another leucocyte count, on March 1, was 1,950 and showed marked leucopenia and a shift to the left, with the appearance of metamyelocytes in the blood stream. The differential count showed polymorphonuclear neutrophiles, 27 per cent; stab forms, 40 per cent; lymphocytes, 23 per cent; monocytes, 1 per cent; metamyelocytes, 8 per cent; eosinophiles, 1 per cent.

On March 2, marked prostration was present. The blood pressure was 84/51. Intravenous fluids and blood transfusion were given. There was marked increase in the bleeding time, as shown by prolonged bleeding from intravenous needle wounds. In one instance bleeding continued from a needle puncture for one and one-half hours. The patient died, apparently from severe prostration, with a temperature of 103° F., three days after the last injection and after a total of only 12 mg. of the drug had been given in seventy-two hours.

As the autopsy findings in this case and in Case 3, in which death occurred during treatment, will be presented in detail elsewhere, only the pertinent findings will be mentioned here.

Histologically, the tumor of the right breast presented the typical features of a scirrhous duct carcinoma, in which the tumor cells frequently showed degenerative changes, especially prominent in the nuclei. Mitotic figures were not infrequent, but none had progressed beyond the metaphase. The stroma was edematous and showed hyaline degeneration. There was definite degeneration as compared to the original biopsy specimen. Clumps of tumor cells were found in the lungs. There was nuclear degeneration in all the parenchymatous organs, more especially in the liver; hyaline degeneration of skeletal muscles; increased mitosis, with evidence of degeneration in the form of chromatin fragmentation; myelin degeneration of the peripheral nerves; and hypoplasia of the bone marrow.

CASE 3.—R. B., a 44-year-old negro, had a history of rectal pain, altered bowel habit, and bloody stools for the previous six months. Although he had lost 40 pounds (18 kg.) in weight, he was still in good physical condition. There was a hard, fixed carcinomatous tumor in the rectum, beginning at the mucocutaneous border and almost completely encircling the bowel. Biopsy revealed a gelatinous adenocarcinoma.

Colchicine was given intramuscularly as follows: 2 mg. on Feb. 23, 1939; 4 mg. on Feb. 24; 6 mg. on Feb. 25; 8 mg. on Feb. 26; and 8 mg. on Feb. 27.

The patient was unaffected until Feb. 25, when he complained of increased pain in the rectum, accompanied by rather severe diarrhea. On Feb. 27, the temperature rose to 100.5° F. and continued intermittently elevated throughout the course. On Feb. 28, the patient felt tired and weak; the radial pulse was barely palpable, and he was obviously very ill. Intravenous fluids and supportive treatment were given, but he continued to be weak. On March 2, he was unable to get out of bed, and on March 4 developed signs of bronchopneumonia. A roentgenogram of the chest showed evidence of bilateral bronchopneumonia. The offending organism was type 7 pneumococcus. Oxygen was administered nasally and 100,000 units of type 7 antipneumococcus serum were given. The patient became progressively worse, and expired on March 7, with a high temperature and in a violent delirium. As in Case 2, profound leucopenia, with a shift to the left, developed, from which partial recovery had occurred at the time of death (Table II).

original size. The ulcerating area about the nipple was healed over, and the nipple began to protrude. After this injection, the remnant of the mass in the axilla, which had shrunk to about 3 cm. in diameter, became a little larger and moderately painful.

On March 31, 2 mg. of colchicine was given.

On April 5, the tumor seemed to be increasing in size, so the patient was given daily injections of 1 mg. of colchicine for the next six days.

By April 23, the tumor in the breast was growing rapidly; the mass in the axilla recurred as rapidly as it had disappeared. In addition, a mass of metastatic glands appeared above the right clavicle. The epithelium which had grown over the ulcerated area began to break down. A moderate amount of pain was present. By May 15, the carcinoma was increasing in size at a much accelerated rate. A full head of hair had begun to regrow.

Table I gives a résumé of the blood picture. There was marked leucopenia, with a shift to the left. The anemia was much more profound than the blood count would indicate, for it was taken after a blood transfusion had been given and recovery had begun.

TABLE I

BLOOD PICTURE IN COLCHICINE POISONING

CASE V. W.

DATE	COLCHICINE MG.	LEUCOCYTE COUNT	POLYMORPHONUCLEAR NEUTROPHILES	STAB FORMS	LYMPHOCYTES	MONOCYTES	NEUTROPHILE MYELOCYTES	NEUTROPHILE METAMYELOCYTES	EOSINOPHILES	BASOPHILES
2/ 2/39*		8,950	53	12	21	9			4	1
2/ 6/39	1									
2/ 7/39	2									
2/ 9/39	4									
2/10/39	7									
2/14/39		4,000	41	26	11	22				
2/15/39	7	1,200	8	4	78	8	1	1		
2/16/39		1,100	3	29	61	5		2		
2/21/39		8,500	8	49	25	15	3			
2/28/39†	2	6,800	62	13	19	6				
3/10/39	2									
3/27/39	4									
4/13/39‡		7,500	66	10	17	5			1	1

*R.B.C., 3,900,000; Hb, 10 Gm.
†R.B.C., 2,500,000; Hb, 7 Gm.
‡R.B.C., 4,300,000; Hb, 11.9 Gm.

CASE 2.—D. C., a woman, 65 years of age, first noticed a "lump" in the right breast in April, 1938. This tumor was subcutaneous and slightly superior to the nipple. It grew progressively larger, broke through the skin during the summer of 1938 and involved the nipple, becoming a large fungating mass. On admission to the hospital, this mass was a raised plaquelike area about 1 cm. above the skin level, measuring 7.5 by 8 cm. The entire breast was firm, indurated, and fixed to the underlying pectoralis muscle. The whole mass with the muscle, however, was freely movable on the chest wall. A few axillary glands were palpable but not fixed.

Autopsy revealed bilateral confluent bronchopneumonia. The carcinomatous process was confined to the rectum. The histologic appearance of the tumor was that of a colloid carcinoma in which large tumor cells were scattered irregularly through accumulations of mucinous material. Mitotic figures were rare. Little change was noted in the histologic appearance as compared to the original biopsy. The lungs showed bronchopneumonic areas in which the exudate was composed principally of polymorphonuclear leucocytes. There were hemorrhage and a diffuse infiltration of polymorphonuclear leucocytes into the tissues about the tumor. There were several hemorrhagic ulcers of the cecum measuring up to 1.5 cm. in diameter. The cellular changes throughout the body were the same as for Case 1 except that the bone marrow showed a diffuse myeloid reaction.

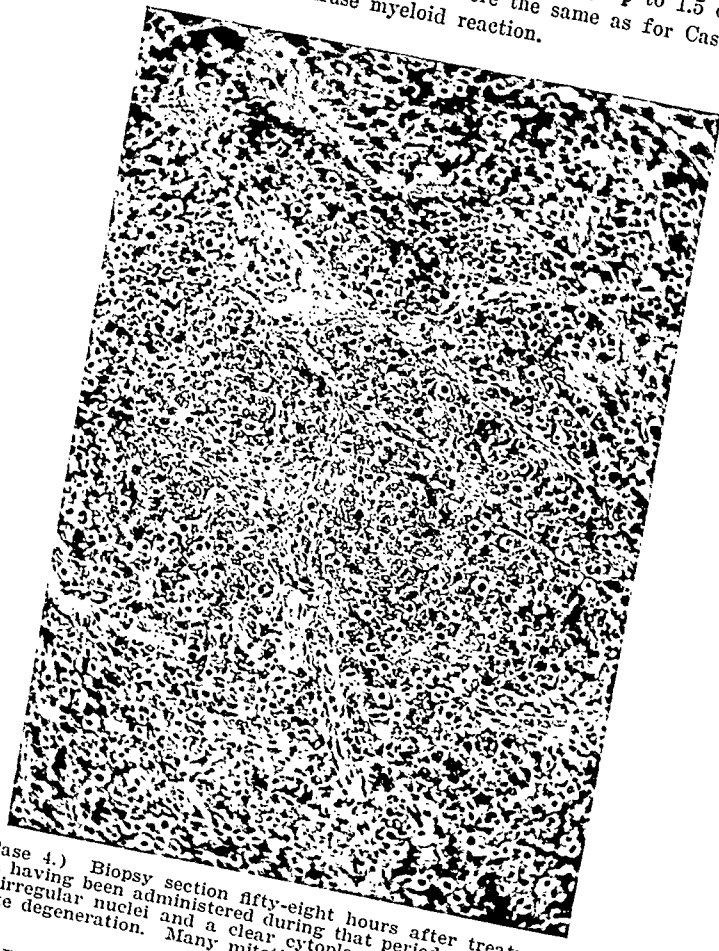


Fig. 7.—(Case 4.) Biopsy section fifty-eight hours after treatment was begun, a total of 10 mg. having been administered during that period. The numerous cells with dark-staining, irregular nuclei and a clear cytoplasm are so-called colchicine figures. There is definite degeneration. Many mitotic figures are present, most of them being in metaphase.

CASE 4.—A. W., a 54-year-old white man, entered the Research and Educational Hospital on Feb. 25, 1938. He had been well until one year previously, when he first noticed a swelling of the left side of the neck, which gradually became larger and later painful. In August, 1937, he entered the Cook County Hospital, where he received extensive high voltage roentgen therapy. The tumor regressed, but recurred, and further roentgen treatment was ineffectual.

On admission to the Research and Educational Hospital, he had a large globular mass occupying the greater part of the neck, extending from just below the ear

TABLE II

BLOOD PICTURE IN COLCHICINE POISONING*

CASE R. B.

DATE	COLCHICINE MG.	LEUCOCYTE COUNT	POLYMORPHONUCLEAR NEUTROPHILES	STAB FORMS	LYMPHOCYTES	MONOCYTES	MYELOCYTES	METAMYELOCYTES	EOSINOPHILES
2/21/39									
2/23/39	2	6,400							
2/24/39	4	8,000							
2/25/39	6								
2/26/39	8								
2/27/39	8								
2/28/39									
3/ 4/39		6,250	42	21	32	2	3		
3/ 6/39		900	3	64	8	21	1	1	2
		10,450	27	58	3	7	3	2	

*Leucopenia as result of colchicine poisoning. Leucocytosis was present 7 days after last injection during terminal bronchopneumonia.

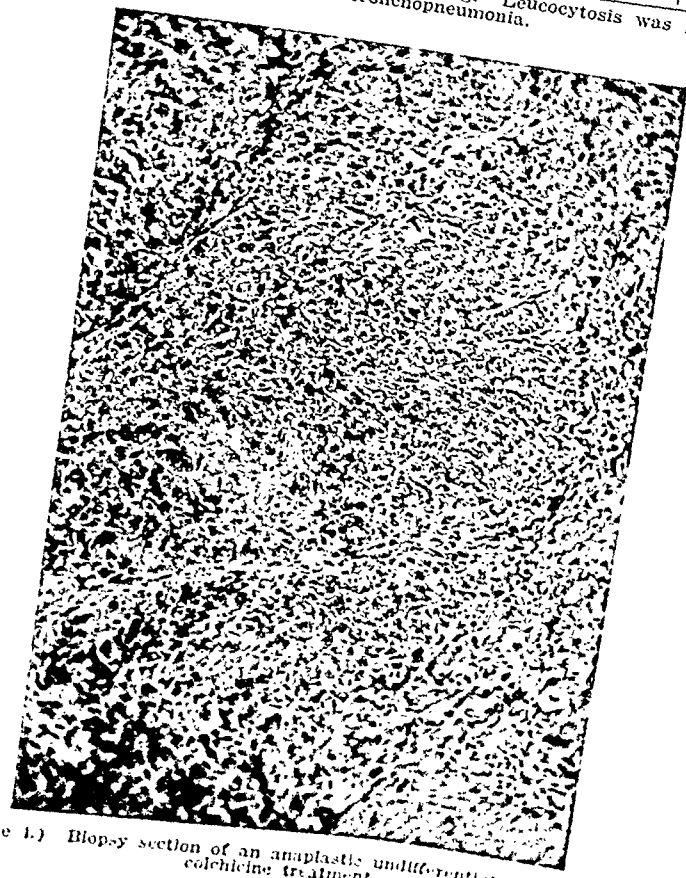


FIG. 6.—(Case 1.) Biopsy section of an anaplastic undifferentiated carcinoma before colchicine treatment.

Autopsy revealed bilateral confluent bronchopneumonia. The carcinomatous process was confined to the rectum. The histologic appearance of the tumor was that of a colloid carcinoma in which large tumor cells were scattered irregularly through accumulations of mucinous material. Mitotic figures were rare. Little change was noted in the histologic appearance as compared to the original biopsy. The lungs showed bronchopneumonic areas in which the exudate was composed principally of polymorphonuclear leucocytes. There were hemorrhage and a diffuse infiltration of polymorphonuclear leucocytes into the tissues about the tumor. There were several hemorrhagic ulcers of the cecum measuring up to 1.5 cm. in diameter. The cellular changes throughout the body were the same as for Case 1 except that the bone marrow showed a diffuse myeloid reaction.

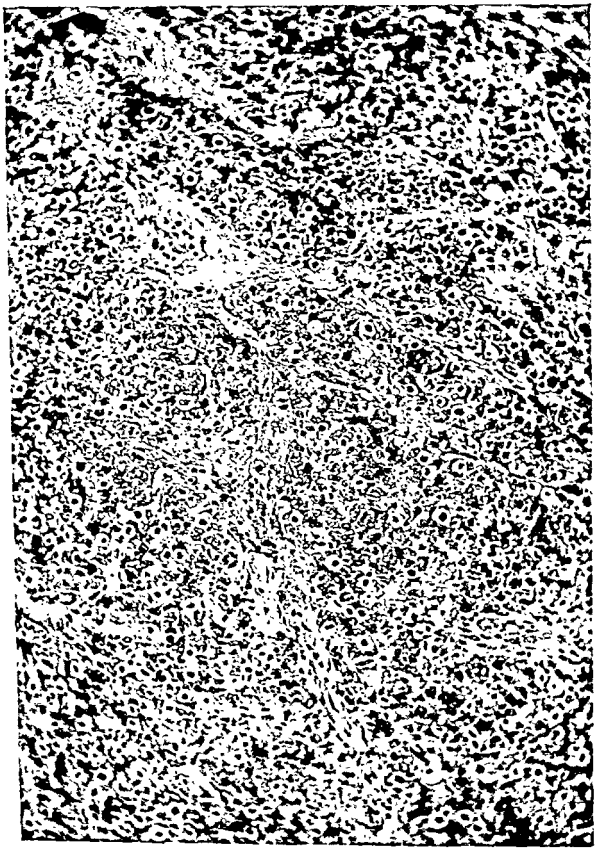


Fig. 7.—(Case 4.) Biopsy section fifty-eight hours after treatment was begun, a total of 10 mg. having been administered during that period. The numerous cells with dark-staining, irregular nuclei and a clear cytoplasm are so-called colchicine figures. There is definite degeneration. Many mitotic figures are present, most of them being in metaphase.

CASE 4.—A. W., a 54-year-old white man, entered the Research and Educational Hospital on Feb. 25, 1938. He had been well until one year previously, when he first noticed a swelling of the left side of the neck, which gradually became larger and later painful. In August, 1937, he entered the Cook County Hospital, where he received extensive high voltage roentgen therapy. The tumor regressed, but recurred, and further roentgen treatment was ineffectual.

On admission to the Research and Educational Hospital, he had a large globular mass occupying the greater part of the neck, extending from just below the ear

to 4 cm. above the clavicle. It was tender and firmly fixed to the underlying tissues. The results of physical examination were otherwise negative except for marked emaciation. A roentgenogram of the chest revealed a round, smooth mass in the right thorax, presenting in the lower lung field and evidently coming from the lower posterior mediastinum, just above the diaphragm.

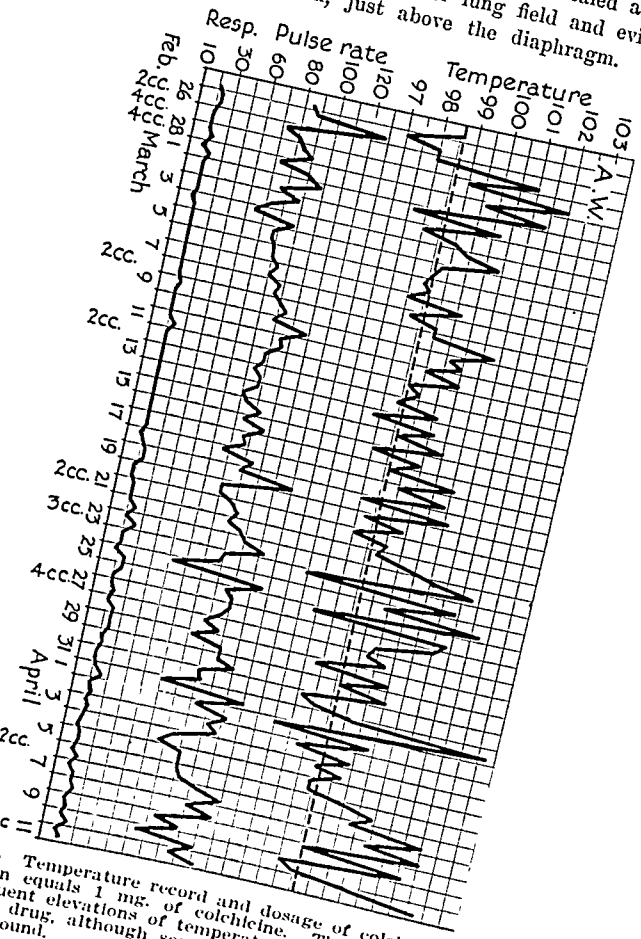


Fig. 8.—(Case 4.) Temperature record and dosage of colchicine. One cubic centimeter of the solution equals 1 mg. of colchicine. The temperature rose after the second dose. Subsequent elevations of temperature seemed to be correlated with the administration of the drug, although some of the fever was undoubtedly due to the extensive sloughing wound.

A biopsy specimen taken before treatment with colchicine was begun (Feb. 26, 1939) showed a very anaplastic carcinoma composed of undifferentiated epithelial cells (Fig. 6). On the third day of treatment, after 10 mg. had been administered, a biopsy specimen showed marked changes (Fig. 7). There were innumerable mitotic figures throughout all fields, most of them being in metaphase. There was vacuolation and evidence of degeneration of the carcinoma cells. The patient became ill after this total dose of 10 mg., so treatment was temporarily suspended. Later (March 4) a biopsy showed the tumor cells in a recovery stage with few mitoses. The cells, however, were hyalinized and degenerated and contained poorly staining or pyknotic nuclei.

Fig. 8 gives the dosage of colchicine with the temperature record. Some elevation of temperature occurred with all our patients in this and other series when

ever toxic doses were administered. In this patient some of the elevation in temperature was due to the sloughing of the tumor, but some must have been due to the colchicine itself, for, as can be seen, it corresponded rather closely to the doses administered. The leucocyte count during this period varied from 12,500 to 5,350 cells per cubic millimeter. There was no polymorphonuclear leucopenia.



Fig. 9.—(Case 4.) Sloughing process four weeks after beginning of treatment with colchicine.

Additional observations were as follows: On March 4, the skin over the tumor, formerly pink, was cyanotic. On March 12, the tumor was more movable. On March 21, the surface was becoming necrotic, and on March 24, a definite slough appeared (Fig. 9). On March 27, necrosis was progressing rapidly. The tumor was débrided. It was found to consist of a cheesy mass of necrotic tissue without blood supply and without sensation. Almost the entire tumor could be scooped out easily, and the dissection was stopped only out of respect for the large vessels deep in the neck. The sloughing process continued and left only a thin rim of live tumor at the periphery. The patient was ill and had a fever during this period.

On April 12, the center of the tumor continued to slough out (Fig. 10). However, the periphery began to extend with rather startling rapidity. From this point on the course was downhill, the tumor growing at what seemed to be an increased rate.

On April 30, the patient died of cachexia. The leucocyte count during the last period remained above 20,000. Autopsy did not reveal the microscopic changes of

acute colchicine poisoning. The tumor in the chest, which had arisen in the posterior mediastinum, consisted of a cystic mass with relatively thin carcinomatous walls, and a necrotic, liquefied center. We are of the opinion that liquefaction of this mass was probably due to the degenerative effect of the colchicine.

In this case the colchicine undoubtedly had a profound effect on the carcinoma, at first producing massive necrosis and later distinct stimulation of the malignant process.

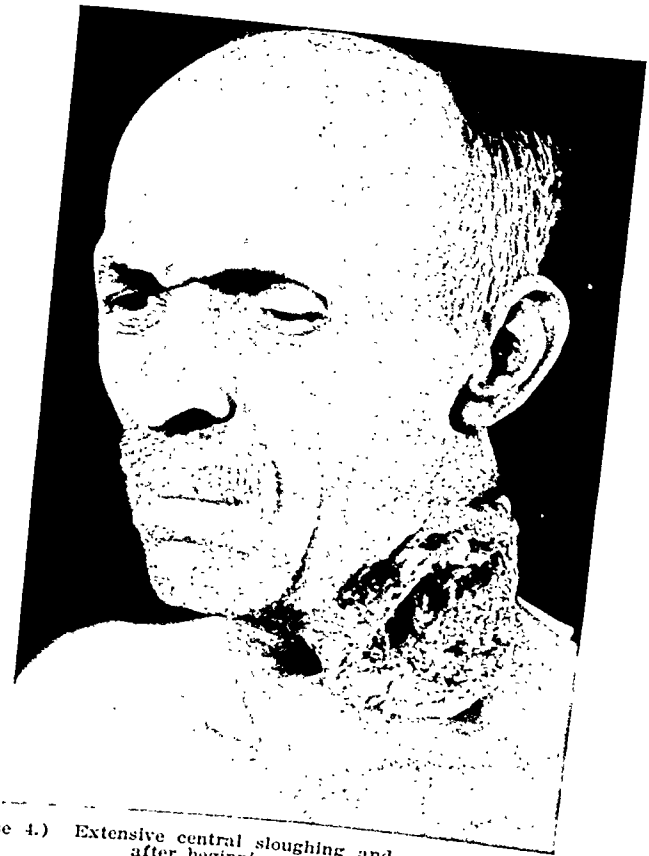


Fig. 10.—(Case 4.) Extensive central sloughing and growing periphery six weeks after beginning of treatment.

COMMENT

In Case 1 colchicine given in toxic doses produced a profound reduction in the size of the carcinoma, this effect being followed by an equally profound increase in size. In Case 4 a much less toxic dose caused the death en masse of all but the rim of a large carcinoma, this effect being followed by stimulation of growth at the periphery. Thus there was first a definite inhibition, followed by a definite stimulation. This contradictory effect is apparently a characteristic of all carcinogenic agents. Haddow and Robinson[6] have investigated a large series of carcinogenic agents and found without exception that all have likewise an inhibitory effect. Haddow[7] has suggested that carcinogenic agents operate by pro-

ducing interference with certain normal functions of the cell, particularly growth, in such a way as to induce variation in the characters affected. He also stated that there is a certain degree of parallelism between this growth-inhibiting power and tumor-producing capacity shown by radioactive agents and the carcinogenic hydrocarbons. We do not know definitely that colchicine is a carcinogenic agent, but we assume that it is and that its effect is similar to that of the proved carcinogenic drugs.

From the clinical findings in colchicine poisoning, such as the resulting aplastic anemia and the loss of scalp hair, and from the autopsy findings of mitotic disturbance in practically all growing cells, it is clear that the drug is a powerful general mitotic poison. Although the rapidly growing cancer cells are more susceptible to the poison, the concomitant general toxic effect is much too great to expect any curative effect. If such a mitotic poison were taken up more or less specifically by the cancer cells, benefit might be derived, a hypothesis not beyond the realm of possibility.

SUMMARY

Colchicine was given in toxic doses to four patients with advanced carcinoma. Two of these died of colchicine poisoning, which was accompanied by fever and by severe agranulocytic leucopenia, anemia, and a tendency to bleed, evidence of suppression of all the blood-forming elements. In the other two patients there was histologic evidence of degeneration in the tumors within a few days and gross evidence of sloughing and absorption within a few weeks. In both patients the tumors, after the primary regression, began to grow at an accelerated rate.

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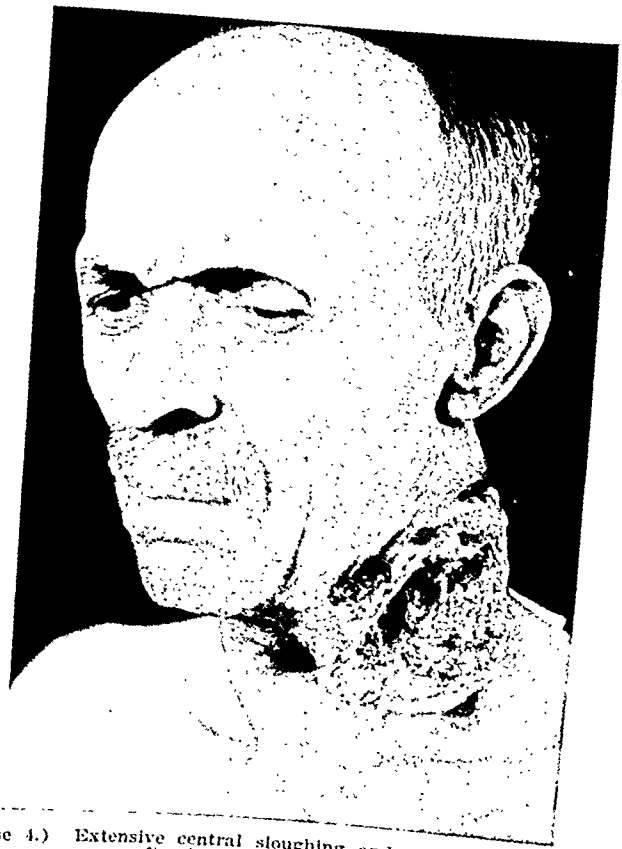


Fig. 10.—(Case 4.) Extensive central sloughing and growing periphery six weeks after beginning of treatment.

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catheter in the postoperative period, was frustrated because of the complicating urosepsis.

The question of when such an indwelling catheter should be removed with safety has not received the proper answer as yet. It is usually left to the discretion of an intern who will remove it whenever the "spirit moves him." *It was never considered a problem since the urosepsis was blamed on the trauma of the inlying catheter itself and not on the premature catheter removal.*

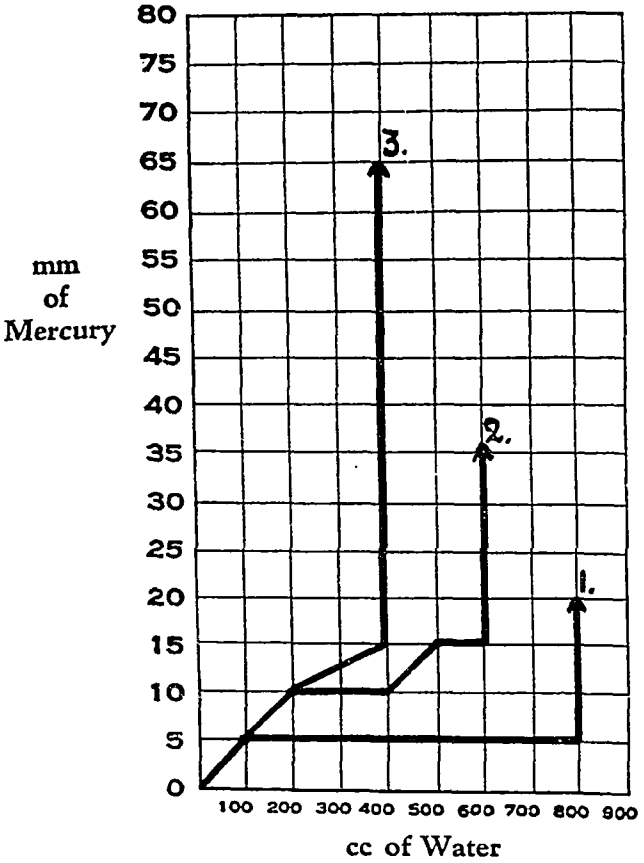


Fig. 3.—Illustrating the cystometric improvement in a case of neurogenic bladder following spinal fracture. *1*, On admission; 2, in interval two weeks later; *3*, return to normal with a bladder-wall pressure of 65 mm.; safe time for catheter removal.

We know today that the urosepsis present will not complicate the case to any extent provided competent drainage is established and, what is more important, is maintained twenty-four hours a day. One must consider every possibility of a faulty extravesical drainage system interfering with a free and uninterrupted flow of urine. Catheter, tubing, position of patient, and height of bottle, etc., are important factors. We employ a catheter with two eyes (Robinson), size 18 to 20 F., placed in proper position, immobilized by strapping to the thigh (Fig. 1), con-

CYSTOMETRIC TIMING OF CATHETER REMOVAL FROM A NEUROGENIC BLADDER

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(From the Mount Sinai Hospital and the University of Pennsylvania Medical School)

THE PROBLEM of the timely removal of an indwelling catheter from an infected neurogenic bladder is a very serious one, since precocious removal may precipitate urosepsis with pyelonephritis and distant septic metastases. Such a catastrophe is often fatal and, if combated, it is only after a long siege of grave morbidity. Many an excellent neurosurgical or other surgical procedure, requiring an indwelling

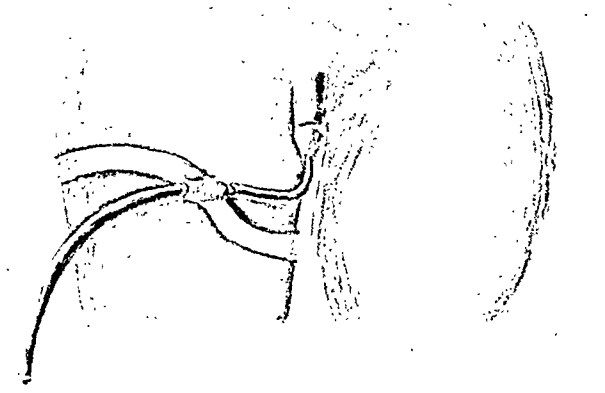


Fig. 1.—Showing the importance of fixation of the catheter with adhesive tape to the thigh, thus relieving the irritating weight and pull of the drainage tube to the bottle and preventing it from coming out.

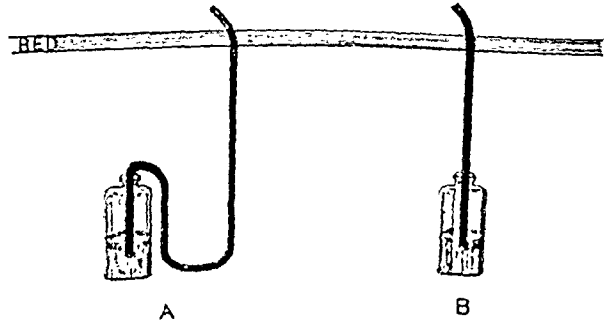


Fig. 2.—Illustrating the proper and improper ways of drainage from the catheter to the drainage bottle. *A*, Note excess of tubing holding an amount of urine constantly, thus acting as an obstructing factor; *B*, straight drainage to bottle eliminates obstruction.

Received for publication, November 10, 1939.

After the insertion of the indwelling catheter, a cystometrogram is taken and the data used for comparison with subsequent determinations, noting the progress of the recovery of the bladder-wall musculature. Only when complete recovery is indicated by the cystometer does the removal of the catheter become a safe and well-timed procedure (Fig. 3). The maximal voluntary pressure (the voluntary pressure obtained when the patient strains to void on maximal filling of the bladder) is the first cystometric factor to improve and approach normalcy. The other two factors, namely, the first desire to void and the pressure curve, are much slower in improvement and still show abnormal readings after the patient is already able to void voluntarily. We, therefore, consider in this issue the maximal voluntary factor as the main criterion for catheter removal. Fig. 4 graphically demonstrates the improvement of the maximal voluntary pressure in a postoperative neurogenic bladder over a period of six weeks. The safe period for catheter removal begins only after the pressure has returned to 60 mm. Any attempt to remove the catheter before this pressure has been reached (unsafe period) may readily precipitate generalized urosepsis. Following this rule, we have been able to reduce our morbidities to a minimum. We feel that such handling of an infected neurogenic bladder, based on cystometric evidence, will greatly enhance the many neurosurgical and other procedures, eliminating a grave morbidity and many fatalities.

nected to a drainage tube just long enough to hit the bottom of a drainage bottle hanging from the side of the bed. Any excess rubber tubing hanging outside the drainage bottle is cause for improper drainage. The amount of urine stagnated within this excess volume acts as an obstruction to the outflow and can be the cause of fever (Fig. 2).

The infected neurogenic bladder differs greatly from an infected normal one. It is more sensitive to trauma and reacts to the slightest increase of intracystic pressure. We, therefore, do not irrigate the bladder proper, as we feel that the slightest distention of such a bladder will cause a septic shower. But we do insist on daily or even twice daily washing of the drainage tube from the catheter to the bottle. We boil this drainage tube in a 10 per cent phosphoric acid every other day to remove the phosphate deposit which decreases the lumen of the tube, thus hindering drainage.

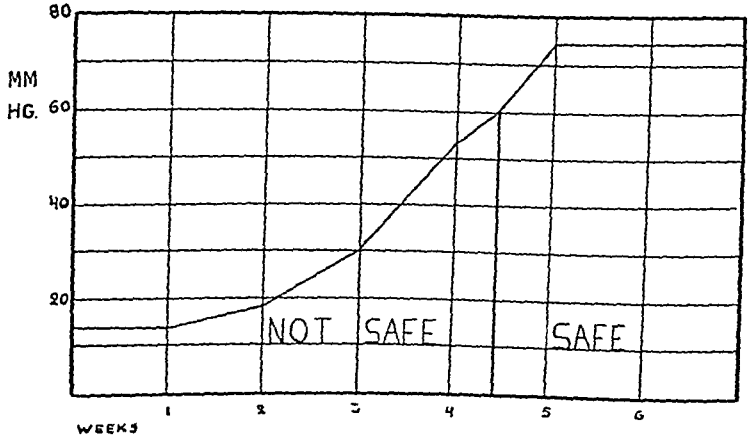


Fig. 4.—Graph illustrating the gradual rise in the maximal voluntary bladder pressure determined by the cystometer in a case of postoperative neurogenic bladder over a period of six weeks. The safe period for catheter removal begins only after the pressure has returned to 60 mm. (low normal). The period before reaching this pressure is termed not safe, as the catheter removal at this time may precipitate generalized urosepsis.

We encounter three situations after the removal of the indwelling catheter: (1) complete emptying of the bladder, (2) complete retention with overflow, (3) frequent voiding with residual bladder urine. In the first two situations no reaction will occur, provided one does not wait more than four hours for the reinsertion of the catheter if the patient is not voiding. In the last situation one must carefully and frequently determine the amount of residual present. If this residual exceeds 100 c.c., the reinsertion of the catheter is imperative. We wait until further restoration of function has occurred, otherwise a continued shower of bacteria will ensue, due to frequent bladder contractions. We found that the timing of the catheter removal does not have to be left to one's judgment but can be established scientifically by means of the cystometer.

included in our study, very few were pregnant when first seen. The two hospitals from which the clinic patients were taken have no obstetrical out-patient departments. The patients for the most part presented themselves primarily for the relief of the veins or for symptoms caused by the veins. This inequality between men and women would bear direct evidence to Sicard's[2] theory of the association of the ovarian endocrine system with the development of varicose veins. This fact might also help to explain the high incidence of veins developing in women between the ages of 40 and 49 years, a period of years corresponding roughly to the menopause.

In considering predisposing factors (Table II), the classification was divided into primary and contributory causes. To explain, when a woman noted her varicosities commencing in association with a pregnancy, but also gave a family history of varicose veins, pregnancy was considered the primary predisposing cause, and the family history the secondary or contributory cause. In those instances in which a woman developed veins before her marriage or before any pregnancy, and in which she gave a family history of veins, the primary cause was recorded as being hereditary. There are 42 cases here included of women who had no pregnancies, but who had a positive family history. The patients included under undetermined causes frankly could be put in no category. One case, for example, was that of a woman, unmarried, whose family history was negative. She had no children, and had her household cared for by three servants. There was no past history of disease or operations. Similarly, there was the case of a man, a desk clerk, who hated athletics, had been well all his life, and whose family history was negative.

TABLE II

PREDISPOSING CAUSES

	PRIMARY		CONTRIBUTORY	
	MALE	FEMALE	MALE	FEMALE
Pregnancy		273		24
Family	56	84		73
Phlebitis	9	23	4	5
Trauma	7	6		
Undetermined	80	39		
No history	7	16		

From our findings we conclude that childbearing, a positive family history, plus a smattering of phlebitis and injuries, are the underlying factors in the production of varicosities. The mechanism of the occurrence of veins during pregnancy is not completely understood. The fact that large fibroids often do not cause varicosities makes it questionable as to whether the rapid enlarging uterus of pregnancy could cause sufficient back pressure to produce hypertrophy and

A STUDY OF VARICOSE VEINS

REPORT OF 600 CASES

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THIS paper is the report of 600 consecutive, unselected cases of varicose veins which were studied and treated under our supervision. The total number of cases is comprised of two groups of private patients and two groups from clinics. The private patients make up about one-half the total number. The clinic patients were drawn from the Peripheral Vascular Clinic of the Presbyterian Hospital, and the Varicose Vein Clinic of St. Michael's Hospital, both in Newark, in a ratio of about 5:3.

Many studies and reports concerning the treatment of varicose veins have appeared in the literature. However, a relative paucity of statistical data regarding the predisposing causes and causative factors exists. We believe this report covers the largest number of cases to be uniformly studied from every angle. Larger reports have been made which merely covered injection statistics. It would also seem that these cases might be considered fairly representative as they are drawn about equally from different economic and social strata, clinic and private-patient sources.

Table I shows that varicose veins occurred in 441 women and 159 men, an approximate 3:1 ratio. We feel this to be about the average ratio, although in the 285 cases recently reported by Ochsner and Mahorner,[1] 247 were females and 38 males. These authors explain the high incidence of females by stating that most of the patients presented themselves, not because of varicosities, but because of pregnancy with which the varicosities were associated. In the patients

TABLE I

AGE	MALE	FEMALE	PERCENTAGE
10-19 yr.	1	1	0.33
20-29 yr.	16	27	7.1
30-39 yr.	20	100	20.0
40-49 yr.	42	131	28.8
50-59 yr.	43	112	25.8
60-69 yr.	26	53	13.1
70 plus yr.	11	17	4.6
	159	441	
	Color		
	White 594		
	Black 6		

Received for publication, November 6, 1939.

TABLE IV

NUMBER OF YEARS VARICOSE VEINS PRESENT

YR.	MALE	FEMALE
0- 5	49	68
6-10	31	92
11-15	15	82
16-20	27	68
21-25	7	39
26-30	10	38
31-35	2	20
36-40	1	14
40 plus	3	7
Not given	14	13
	159	441

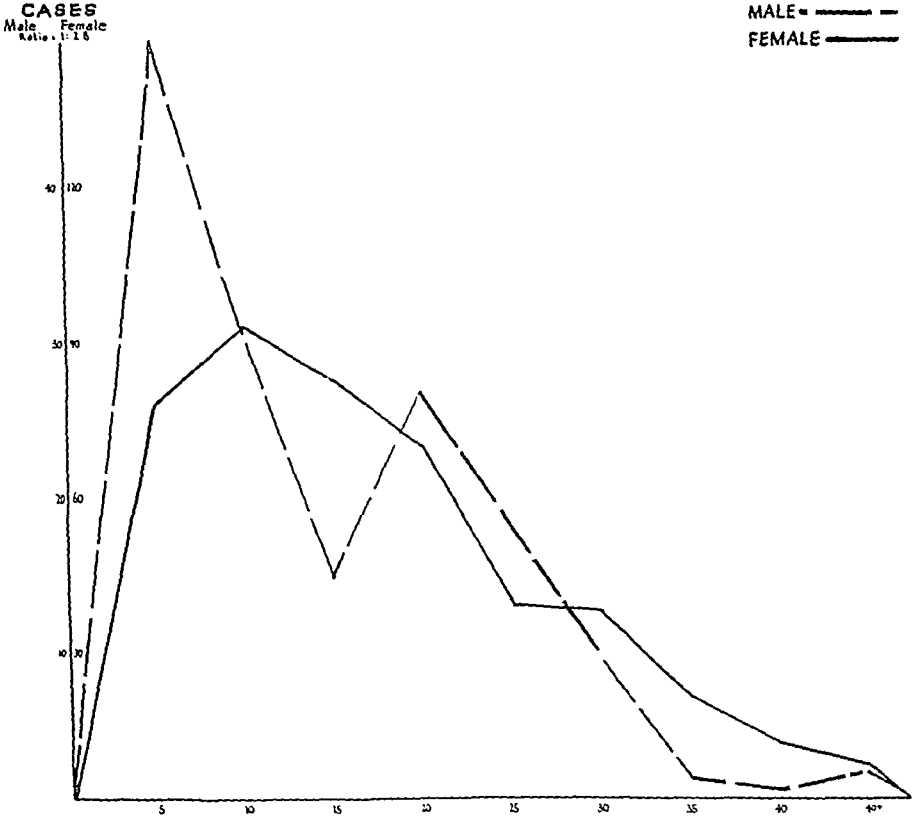


Fig. 1.—Showing that most men seek treatment relatively early, while women endure their varicosities for many years.

We have another striking example of the difference between the sexes when we consider the age at which veins appear (Table V). In women veins develop most commonly in the childbearing years. In the decade between 40 and 50 years, corresponding to the menopause, they also appear in quite a few instances. This fact again points to

dilatation of the vein walls which we so often see during pregnancy. In some instances the varicosities possibly develop too early in the pregnancy to be associated with an enlarging uterus which is causing pressure on the iliac veins, with resultant back pressure in the extremities. The endocrine factor must be considered. Whatever the mechanism, pregnancy is the most common predisposing factor.

Table III shows the definite relationship between the formation of varicosities and a congenital weakness of the vein structure. Of this series 58 per cent had cases of varicosities in the immediate family, some in many members of the family. The private patients analyzed in this study, who on the average were able to give a better family history, showed an even higher percentage. These figures are at great variance with those of McPheeters and Anderson,[3] who claim a hereditary factor in from 6 to 10 per cent of their cases.

TABLE III

FAMILY INCIDENCE

1 member in family with history of varicose veins	179 cases
2 members in family with history of varicose veins	53 cases
3 members or more with history of varicose veins	14 cases
Negative	196 cases
Unknown	158 cases

Occupation would seem to play a part in the development of varicosities only when associated with a hereditary or acquired disease weakness. It has been contended that body strain, especially standing occupations and athletics, predisposes the individual to varicose veins. However, it is a fact[4] that the laboring class suffers less from varicose veins than does the white-collar group.

People seem to get along for years with varicose veins without seeking treatment, even while suffering much discomfort. They often continue until an ulcer or phlebitis develops, or possibly until a rupture of a varicosity occurs. Table IV shows that women delay treatment longer than men, despite the fact that, for cosmetic reasons, we would expect the women to present themselves for treatment earlier. Men, however, seek treatment quickly, possibly because of the demands of their occupations or just because they are less enduring. Fig. 1 demonstrates visually the facts shown in Table IV. This point is stressed to show that, although varicose veins in some cases are very disabling, are surely disfiguring, and are usually painful to some degree, people apparently can endure them and still carry on their duties. In 44 per cent of the total cases studied, abnormal veins were present for more than fifteen years before the individual sought treatment.

TABLE V

AGE AT WHICH VEINS FIRST APPEARED

AGE	MALE	FEMALE
0- 9 yr.	4	1
10-19 yr.	17	41
20-29 yr.	31	179
30-39 yr.	35	114
40-49 yr.	39	65
50-59 yr.	16	25
60 plus yr.	3	2
Not given	14	14
	159	441

delenburg test. End results will be unsatisfactory unless this type of case is treated by combined ligation and injection. Approximately 1 case in 4 (24 per cent) did not need surgery, but careful study of the veins and their valve competence is necessary to pick out these patients. When a ligation is not indicated, the treatment consists of injections alone.

TABLE VI

LIGATIONS NECESSARY

One leg	226
Both legs	214
None needed	143
Untreated	17
Total	600

During the past year we have been doing a two-point ligation, if the Ochsner-Mahorner tourniquet test demonstrates the valves of the communicating vein to be incompetent. By doing the two-point ligation, we have obtained a firmer thrombus, and also hope to prevent the recurrences caused by the reflux of blood through the communicating veins recanalizing the formed thrombus. The vein is ligated high at the fossa ovalis, and the second point is done below the entrance of the lowest communicating vein. This second point is not always easy to determine, but it is usually below the knee. In doing the high ligation, the operation is done under local anesthesia, and the patient is not put to bed after the operation. We feel it is better for a patient to be up and about after a ligation than to be a bed patient. With slightly restricted activity, the patient still keeps up his normal circulatory flow and there is less danger of complications than if the patient is put to bed with the resultant circulatory slowing. Many of the patients operated upon were in the decades of life over 40 years. We have carried out ambulatory ligation successfully, without untoward results, in all cases covered in this report. We feel that by using the following technique any danger of postoperative bleeding due to activity is eliminated.

the possible importance of the presence or absence of the ovarian secretion as a possible factor in the development of varicosities. The incidence in men, however, increases in the succeeding decades up to 50 years of age. The oldest patient to be treated was 91 years of age and the youngest 7 years. Fig. 2, graphically illustrating the statistics given in Table V, clearly shows a great difference exists.

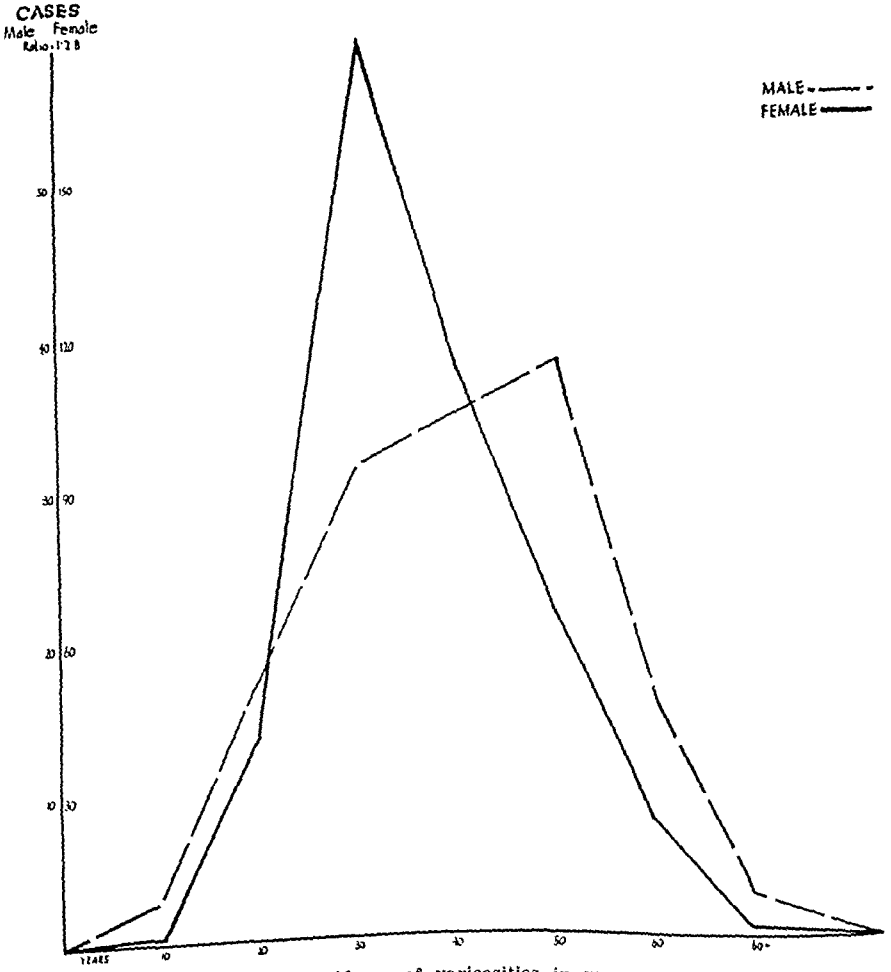


Fig. 2.—Showing the high incidence of varicosities in women between the ages of 20 and 40 years, and the increasing incidence in men up to 50 years.

TREATMENT

Ligation of the saphenous vein was found necessary in 74 per cent (Table VI), and almost as many patients required the operation on both legs (36 per cent) as on one leg only (38 per cent). A high ligation was performed on those cases in which incompetent valves were demonstrated in the long saphenous vein by the Brodie-Treu-

preferable from a cosmetic standpoint. It is true that the treatment can be shortened and fewer injections can be given with immediate retrograde injections at the time of operation, but we are partial to a longer period of treatment. Most of the patients are very desirous of having the appearance of their legs improved as much as possible. Another fact to be considered is that the patients are told that they can continue their daily routine while under treatment, a point which seems very imporant to most of them. With a retrograde injection at the time of ligation, there is often a marked chemical phlebitis which necessitates bed rest and the giving up of duties.

Ulceration usually occurs only after the tissue vitality has been lowered for many years by the stagnant incompetent circulation with its resulting anoxemia and tissue injury. Ulcers under these conditions will then appear with slight injuries or even no trauma. Infection gains easy access to these devitalized tissues. Usually the ulcer appears on the medial aspect of the lower third of the leg. Twenty-five per cent of the cases in this series developed ulcers (Table VII).

TABLE VII

YEARS ULCERS WERE PRESENT BEFORE TREATMENT

NO. OF YEARS	CASES
30 or more	17
26-30	23
21-25	22
16-20	29
11-15	23
5-10	24
0- 5	12
Not given	3
Total	153

The treatment of the ulcers consists in eliminating back pressure and in combating infection. In the acutely inflamed ulcer hot hypertonic solutions are used at first, together with rest and elevation. In selected cases Unna paste boots are applied from the toes to the knee. As soon as the acute inflammation has subsided, which usually requires one to two weeks, ligation is done. It is remarkable to see how quickly the pain will be relieved in an ulcer following ligation. We have seen no untoward complications develop from the ligating of a vein before the ulcer is healed, and we feel that we hasten its closing by doing a ligation and by injecting the feeder veins. In long-standing ulcers, in addition to the factors of stasis and infection, the bases are fibrosed and contracted, and, even when back pressure and infection are eliminated, the ulcer is slow to heal due to poor circulation in its base. We have found that mecholyl iontophoresis is a great aid in speeding up the healing of these long-standing ulcers.

TECHNIQUE OF HIGH LIGATION

The point of incision is first determined by ballotting the vein from below upwards with one hand and following the impulse with the other hand to the highest possible point. This point is usually found to be at the fossa ovalis. The line of incision is carefully marked, with the patient still standing, using a gentian violet-methylene blue solution. We feel this preliminary marking is very important to localize the site of the vein so that later unnecessary hunting will be eliminated. It is well known that the venous system of the body is the most variable of any. Therefore, a purely anatomical determination of the point of ligation will lead to a certain percentage of failures or to a protracted operation and a larger incision due to extensive exploration. About 2 c.c. of 1 per cent novocain is injected subcutaneously and a one-inch transverse incision is made. By blunt dissection the vein is isolated. At this level it is found external to the deep fascia, but beneath the superficial fascia. All tributary veins found entering the saphenous vein in this area are also ligated. The saphenous vein is then doubly clamped and cut after applying a plain No. 0 catgut ligature to either end. A ligature of plain No. 0 catgut then transfixes the ends of the vein distal to the previous ligature and the clamps are removed. The wound is swabbed with ether and closed with two horsehair sutures. This technique has been more fully described by one of us (S. Z. H.) previously.[5]

We have not been employing the retrograde injection of sclerosing solutions at the time of ligation. We have found that a better cosmetic result can be obtained by waiting two weeks and then giving injections. The thought has been that the veins will collapse and contract a great deal following the ligation because of the removal of the hydrostatic back pressure; thus, when injections are given, we are dealing with a smaller vein which will become increasingly smaller when thrombosed. Recently we have injected a few patients at the time of ligation. None of these cases are included in this series. A ureteral catheter has been inserted into the distal vein segment and 20 c.c. of sodium ricinoleate injected. An attempt is thus being made to re-evaluate the value of immediate sclerosing of the distal segment at the time of operation. About five years ago, a group of patients having varicosities and needing a ligation on both legs were selected. On one leg the ligation was done and an interval was allowed for the vein to diminish in size before any injections were given. On the other leg a ligation was done and retrograde injections were given at the time of operation. In this way we attempted to determine which procedure was preferable. We found that the method used in this series, that of ligation followed by an interval before injection, was

diabetes was controlled. We do not consider controlled diabetes a contraindication to treatment. A patient with cardiovascular disease with decompensation should not receive treatment by injection. Lymphangitis, when arising from a dirty ulcer, first should be treated and allowed to subside before treating the veins. We have not treated patients for their varicosities during pregnancy because the veins frequently disappear after parturition and because of the added danger of phlebitis. Patients with advanced arterial disease will often show an improvement in their peripheral arterial circulation when the coexisting veins are treated due to the relief of the venous back pressure with its stagnating effect on the capillary bed.

The results in this series for the most part have been very good. Our most difficult cases have been those with a previous deep phlebitis and marked edema of the leg with ulceration. It is very difficult to treat such cases satisfactorily or to return their circulation to normal efficiency. Iontophoresis of mecholyl has been a great aid in treating such cases, but we must admit that the prognosis usually is not good. The use of the two-point ligation has been very successful in aiding the type of vein pathology in which the communicating veins, passing from the deep to the superficial circulation, have incompetent valves. In these cases a high ligation alone is not sufficient to check the reflux and subsequent injections will be quickly recanalized. Whether the routine use of sclerosing agents at time of ligation should be carried out is still an undecided question with us.

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Ochsner and Mahorner[6] mention the use of vitamin B_1 for the control of pain in such ulcers. We have had no experience with this method of treatment, but their results seem very conclusive. We have not found ointments to be of any value in the treatment of an ulcer, but we have successfully used an alcoholic solution of methylene blue and gentian violet to lower the bacterial count and to stimulate healing.

An ideal sclerosing solution should give maximum thrombosis, with minimum pain, without producing allergic reactions, and without causing any tissue necrosis. There is no solution which meets all these requirements. In general the stronger solutions, such as invert sugar solution, hypertonic saline solution, phenol preparations, and quinine, are painful and will cause a marked sloughing if deposited outside the vein. They do produce, however, a more extensive and quicker thrombosis. The preparations of morrhuate, monolate, and linseolate, cause less pain, are less apt to cause tissue necrosis when deposited outside the vein, but have somewhat less sclerosing ability. They, as well as quinine, do cause anaphylaxis. We have had twelve cases of severe anaphylactic reactions following the use of a 5 per cent sodium morrhuate solution. These reactions usually appear after the patient has had six or more injections and at a time when the doctor feels sure that the patient is not sensitive to the drug. A solution containing 30 per cent invert sugar and 10 per cent sodium chloride has been used routinely for the large veins. This causes a severe muscle cramping which lasts about one minute. The resulting thrombosis is good and sensitivity never occurs. For the smaller veins 5 per cent sodium morrhuate is used. The individual dose is rarely more than 2 c.c. The sugar solutions may be injected in doses of from 5 to 20 c.c. It is well to emphasize that any solution deposited outside the vein in large enough quantities will give a slough.

There are several contraindications to treatment. Block of the deep venous return is the most important. A past history of phlebitis, plus the abnormal appearance of the leg, may cause one to suspect a block of the femoral vein. The Perthes' test will quickly demonstrate a venous block. Second, a dirty ulcer should be cleaned up before injections are started, but it is not necessary for it to be completely healed before treatment is begun. During active phlebitis, injections are for the most part contraindicated, although in some cases, as pointed out by Edwards,[7] small doses deposited a good distance from the phlebitic area can be given with no untoward results. Ligations done even in the presence of low grade phlebitis are not dangerous, hasten recovery, and eliminate the further spread of phlebitic areas. A patient with active syphilis should be treated before the veins are sclerosed. There are many diabetics in our series. We have had no complications arising from treatment of their veins as long as the

sections of the mammary gland; they have encountered as many as 150 separate and distinct papillomas scattered throughout one breast. It is true that there may be but one lesion which is producing the troublesome discharge, but painstaking microscopic studies invariably demonstrate active epithelial proliferation into other ducts. Adair,[1] Hart,[18] and Stowers[33] corroborate this view. By performing simple mastectomies in all cases of papilloma, we have been able to demonstrate multiple areas of epithelial hyperplasia in practically all of them (Fig. 1). Not only have we found multiple lesions in the diseased breast, but similar lesions have frequently been demonstrated in

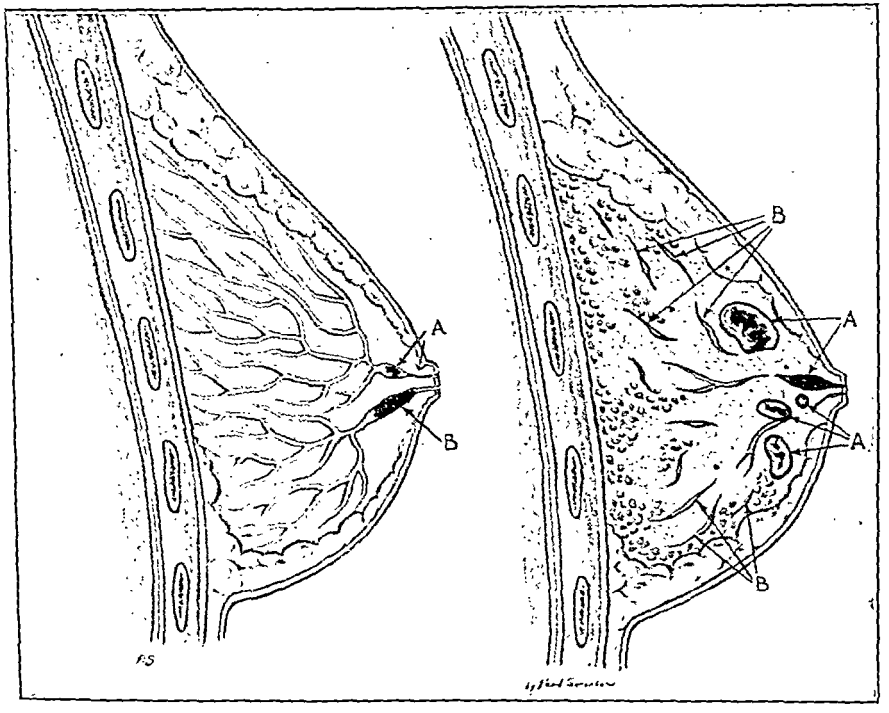


Fig. 1. Fig. 2.

Fig. 1.—*A*, Fibrous occlusion of duct lumen preventing the escape of bloody secretions of the papilloma; *B*, papilloma completely occluding duct.

Fig. 2.—*A*, Multiple intracystic papilloma; *B*, normal ducts.

the opposite gland. Routine mammographic studies of both breasts have furnished incontrovertible evidence of this point. In one instance a simple serous cyst was found in the right breast and the mammograms demonstrated an asymptomatic papilloma in the opposite mammary gland. Cheatle and Cutler[6] and Deaver and McFarland[10] refer to multiple papillomas occurring in the same duct, and this, too, we have corroborated.

It is well to remember that thickening and induration of the duct wall may be produced by deposition of fibrous tissues incident to in-

INTRACYSTIC PAPILLOMA OF THE BREAST

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NEOPLASMS which possess inherent potentialities for becoming malignant present tantalizing diagnostic and therapeutic problems. To accept their apparent benign appearance as a criterion for conservative treatment certainly provides adequate time for carcinomatous transition. To consider these tumors, however, as definitely malignant and to institute radical therapy is to produce unnecessary suffering and mutilation for lesions which may never become destructive. Intracystic papillomas of the breast undoubtedly belong to this group of mutable neoplasms and hence demand special consideration.

PATHOLOGY

Papillomas may arise from any segment of the galactophorous ducts, but they are generally found in the larger lacteal sinuses adjacent to the nipple. They represent hyperplasia of both the epithelial lining and the fibrous tissue components of the milk ducts. The epithelial cells proliferate so much faster than the connective tissue substratum that the tumors are compelled to invaginate into the ductal lumen, and as the villosities grow they fuse, forming a delicate lacy web of soft friable tissue. If these papillomas are floated in water, their branching arborescent structures at once become apparent. The central fibrous stalk contains the dilated blood vessels which ramify the fragile villosities and account for the frequent intraductal hemorrhages.

Gross examination quickly demonstrates that the wall of the cyst which contains the papilloma is merely that of the dilated parent duct. The epithelial cells covering the tumor are similar to and continuous with those of the duct itself. The dilated duct usually contains a serous, serohemorrhagic, mucoid, purulent, or pultaceous secretion which consists of degenerating epithelial cells, corpuscles of Gluge, leucocytes, granular debris, cholesterin scales, blood corpuscles, fat globules, bacteria, and amorphous substances. The amount of fluid depends on its rate of production and the patency of the lacteals, for if the estuaries are open there is a continuous but insensible escape of this exudate of which the patient never becomes cognizant. If the duct is completely obstructed by the tumor or by the resulting periductal fibrosis, there will be a complete retention of the secretions, giving rise to the so-called intracystic papilloma.

In reviewing the literature, one gains the impression that papillomas occur as solitary tumors. Cheatle and Cutler,[6] however, have successfully demonstrated the multiplicity of these lesions by making serial

Received for publication, October 25, 1939.

observed a patient who had had a benign intracystic papilloma removed seven years earlier and who reported to him with an infiltrating carcinoma. Stowers[33] encountered three patients having sero-hemorrhagic discharge from the nipple, and in each instance he found papillomas associated with frank carcinoma. Geschickter[15] states that many cases of papillary carcinoma are late manifestations of pre-existing benign papillomas, while Cheatle and Cutler[16] believe that 20 per cent of breast cancers can be traced to cysts or papillomas.



Fig. 3.—Large intracystic papilloma undergoing carcinomatous transition.

In a series of 18 cases we have encountered 2 which exhibited both benign and malignant intracystic papillomas in the same breast. The first case was that of a woman, 28 years of age, who had observed a small tumor in her right breast. A serosanguineous discharge was expressed from the nipple and a pea-sized mass was felt beneath the areola. The tumor was excised and found to consist of chronic cystic mastitis with pronounced intraductal proliferation, tending toward

flammatory or chemical irritation. Adair[2] has clearly demonstrated the presence of butyric and lactic acids in retained secretions of the breast. He feels that these irritating substances enhance epithelial proliferation and desquamation and associated infection which may contribute to the formation of fibrous tissue. Cheatle and Cutler[6] emphasize the necessity of differentiating this fibrotic reaction with its mononuclear leucocytic infiltration from invasive carcinoma. It is imperative that the entire papilloma be examined for malignant changes, for Broders[5] has pointed out that the tip of the tumor may undergo carcinomatous transition, and the base present no evidence of infiltration. Complete study of the entire papilliferous neoplasm is essential before it can be pronounced benign.

The literature contains numerous contradictory views on the ability of papillomas to undergo malignant transition. Evans[13] maintains that duct papillomas are always innocent tumors, while Eberts[12] affirms with equal sincerity that they possess a striking tendency for malignant changes. FitzWilliams[14] states: "It is evident that a large proportion of such tumors [papillomas] do become malignant in the course of time. I would go even further and say there is no evidence to show that all duct cancers have not in all probability passed through this innocent stage." In discussing mammary neoplasms, Geschickter[15] states that papillomas are essentially benign neoplasms and yet in the same article he analyzes 160 cases of papillary adenocarcinoma and says: "The sanguineous discharge from the nipple, the location near the center of the breast, and the microscopic appearance justify the conclusion that many of these papillary cancers are late manifestations in pre-existing benign papillomas." This emphasizes the amphoteric nature of the papilloma and the suspicion with which experienced pathologists are compelled to consider them. It is interesting to note, however, that, regardless of the arguments which are advanced to establish the innocence of these tumors, all essayists invariably insist upon a careful microscopic examination in order to detect the presence of any malignant cells. Why all of these precautions unless these tumors are potentially dangerous?

One's views cannot help but be tinctured by his own experiences and mine has been such that we consider papillomatous lesions to be potentially malignant. Any breast which gives rise to these proliferative epithelial neoplasms is making an abnormal growth response and only time can tell what the final outcome will be. In one instance serous cysts, mazoplastic changes, fibroadenoma, papilloma, intraductal epithelial hyperplasia, and papillary adenocarcinoma were all found within the same breast (Fig. 3). In practically every case in our series, the epithelial cells lining the milk ducts were undergoing definite proliferative changes. FitzWilliams[14] found intracystic papilloma, chronic cystic mastitis and carcinoma in the same breast. Adair[1]

Such a deduction is more apparent than real for only 50 per cent of their own 40 cases had experienced lactation. A careful perusal of the literature revealed but three instances in which papillomas expressed themselves during pregnancy or lactation. Symptoms invariably appear during the resting phase rather than while the breast is actively functioning. It is conceivable that the frequent nursing would keep the ducts evacuated, but still the associated trauma should produce some recognizable bleeding from the estuaries. In our series there were 14 women who had one or more periods of lactation and only 4 nulliparous individuals.

Duration.—It is most difficult to estimate the age of a papillomatous tumor, for in one instance a lesion measuring less than 0.5 mm. in diameter produced an incriminating discharge, while in others tumors larger than walnuts have been accidentally found on routine examination. These neoplasms usually grow slowly; in some cases they have been observed for thirty years without any appreciable change in size. If the tumor produces a bloody discharge from the nipple, the patient usually seeks advice immediately; otherwise, the policy of watchful waiting is followed. In this series, the average time elapsing between the recognition of the lesion and application for medical advice was four and one-half months.

Discharge.—A hemorrhagic or serosanguineous discharge from the nipple is the most frequent symptom of intracystic papilloma. These fragile tumors are so easily traumatized that such simple acts as walking, adjusting a brassière, or slight manual pressure may initiate an intraductal hemorrhage which escapes from the orifices of the nipple. The discharge may be continuous or may occur at weekly, monthly, or even yearly intervals. Cessation of the discharge does not indicate a disappearance of the offending neoplasm but rather a retention of the secretions within the duct or a spontaneous healing of the eroded epithelium. In either event the tumor continues to grow.

It is well to remember that every bleeding papilloma does not produce a sanguineous discharge from the nipple. If the fragile villosities bleed into a patent duct, the secretions escape. If the ductal lumen, however, is occluded by the tumor itself, by fibrous tissue, or by keratinized plugs of debris, the blood will be incarcerated within the ductal lumen (Fig. 2). In some instances the retained intraductal blood clots undergo degenerative changes and form blood pigments and serum which, because they are diluted with desquamated epithelial cells and the products of infection, are so altered that the escaping discharge bears little or no resemblance to blood. Stained smears are frequently necessary to differentiate these modified hemorrhagic secretions from the chocolate-colored grumous material which is seen in chronic cystic mastitis and mazoplasia. Deaver and McFarland[10] found that in only 50 per cent of their cases did the papilloma produce a bloody

papillomatous formation. A simple mastectomy was performed and several similar papillomatous lesions were found in other segments of the breast in addition to a definite intraductal papillary type of carcinoma of a low degree of malignancy.

The second case was that of a male physician, referred to previously, who had observed a yellowish, blood-tinged fluid escaping from the nipple and on examination found a definite tumor in the subareolar region. A biopsy demonstrated only benign papilloma and yet multiple sections of the breast revealed an intracystic papillary adenocarcinoma with metastasis to the subpectoral lymph glands.

Such experiences as these compel us to respect these papillomatous tumors as being potentially malignant and hence to condemn all types of conservative and passive forms of therapy. This is in harmony with the accepted treatment of papillomatous tumors of the colon and bladder, for, even though they are relatively benign, they receive prompt attention before they have an opportunity to become malignant.

CLINICAL MANIFESTATIONS

Age and Sex.—In general, intracystic papillomas are a disease of early middle life, occurring most frequently during the third and fourth decades. However, both extremes may be affected, for FitzWilliams[14] excised a small duct papilloma from the breast of a 19-year-old girl and Hart reported one occurring in a woman 98 years of age. In Williams'[37] series, the average age was 43 years; in Warren's[36] it was 52 years; and in Deaver and McFarland's[10] it was 40 years. Such statistics are misleading, however, for they do not give the actual age at which the lesion developed, but rather the time at which it became manifest. Studies of autopsied material demonstrate that even in the late twenties and early thirties there is frequently a marked proliferation of the intraductal epithelium which must be interpreted as incipient papillomatous tissue. Ebert[12] and Cutler[8] affirm that cystic degeneration of the breast occurs in the second and third decades of life, papillomas in the third and fourth, and carcinomas in the fifth and sixth. They believe, and we agree, that there is a definite evolutionary relationship between these diseases.

Papillomas affect both sexes, being much more common in women than men. David,[9] Greenough and Simmons,[17] Russell,[31] Williams,[36] Hewett,[19] DeMorgan,[11] Silva,[32] Gowland,[16] Worbs,[38] Tietze,[35] Strasser,[34] and Cheret and Unger[7] have observed these intracystic lesions in the male breast. One of our cases, a young man 39 years of age, had had a small intracystic papilloma removed, but the recurrent lesion proved to be a malignant intracystic papillary carcinoma which was infiltrating the duct wall and surrounding matrix.

Deaver and McFarland[10] believe that intracystic papillomas occur most frequently in the breast of parous women, intimating that the functional activity induces hyperplasia of the ductal epithelium.

Examination demonstrated that she had a spontaneous infarct of the right mammary gland secondary to a hypertensive auricular fibrillation. Approximately one-eighth of the breast was involved by the large infarct and all the ducts leading from this segment emitted dark red blood.

It is apparent that bloody discharges from the nipple have little diagnostic significance other than to issue a warning that some abnormal physiologic or pathologic process is present. Complete studies are necessary to determine the etiologic factors. It is true that a sanguineous discharge, in the absence of a palpable tumor, is strongly suggestive of an intraductal papilloma, but confirmation is mandatory before proceeding with treatment.

Pain.—Mastalgia is seldom associated with a papilloma for these tumors grow so slowly that they produce but slight intraductal pressure. Occasionally a sudden sharp pain may announce the occurrence of an intraductal hemorrhage. Infectious processes and mazoplasia are much more prone to produce pain than are the intracystic papillomas, and in the majority of cases it is the associated mazoplasia that accounts for the discomfort.

Tumors.—The very nature of these neoplasms makes their detection by palpation most difficult. Being small in size and composed of soft, compressible tissue, they frequently cannot be distinguished from the breast matrix. If they are large enough to be palpated, they impart a sense of resiliency, often resembling fluctuation. Ninety-five per cent of the papillomas are situated within or directly beneath the nipple in the subareolar zone and arise from the lacteal sinuses. Manipulation of the tumor exerts traction on the parent duct and hence retracts the nipple in the same direction as the applied force. If located within the nipple or immediately beneath it, the expanding growth may push the nipple outward, or in some cases the fibrosis may cause a retraction of this organ. Frequently, a gentle pressure directly over the mass will produce a sanguineous discharge from the nipple, but on several occasions we have been able to elicit the discharge and were still unable to palpate the offending tumor. Extreme caution should be employed in manipulating any mass within the breast for forcible compression can and does disseminate carcinomatous emboli. In this series only 35 per cent of the papillomas could be palpated.

Transillumination studies are frequently valuable in locating the larger papillomas. This is particularly true if there is an associated intraductal hemorrhage or if the duct contains fluids for then they produce distinct shadows. Small, uncomplicated, villous papillomas possess the same translucency as the surrounding tissues and therefore cannot be differentiated.

DIAGNOSIS

The failure of these papillomatous lesions to produce identifying symptoms combined with their pernicious tendency to undergo malignant transformation certainly creates an interesting problem. In

discharge for in 25 per cent they elaborated a serous secretion and in 25 per cent no discharge was observed. Hart[18] emphasized the fact that a macroscopic examination of the excised breast usually revealed the presence of intracystic hemorrhages and collections of fluid which could not be demonstrated clinically.

We feel that it is extremely important to study the nipple and to examine all escaping secretions. In one instance cancer cells were detected in the escaping discharge and at operation an infiltrating duct cancer was found. In two instances gentle stripping massage of the nipples expressed drops of bright red blood and yet the patients were positive there had been no previous bleeding; mammographic studies clearly demonstrated small, nonpalpable papillomas situated in the deeper portion of the nipples themselves in each instance. On the other hand, we have encountered four papillomas in ducts from which no discharge could be obtained and yet subsequent mammograms revealed the ducts to be patent.

Unfortunately a bloody discharge from the nipple is not pathognomonic of a duct papilloma, for it occurs in any condition which produces erosion of the ductal epithelium. Adair[1] maintains that a dark, bloody secretion is usually associated with a duct cancer. Stowers[33] concludes that a hemorrhagic discharge, in the absence of trauma or a palpable tumor, signifies the presence of an intracystic papilloma. Miller and Lewis[26] found a serosanguineous secretion to be associated with carcinoma in 65 per cent of their cases. Judd[24] studied 100 patients whose chief complaint was bloody seepage from the nipple and found that cancer was the provocative factor in 54 of the cases. Occasionally the cause of a serosanguineous discharge cannot be determined. For example, a girl 19 years of age and in the eighth month of pregnancy, sought advice because of a bloody discharge from both breasts. The mammary glands were well developed, and bright red blood could be seen coming from eight estuaries in the right nipple and from eleven on the left. Smears were positive for blood, but no evidence of infection was found. Repeated mammographic studies failed to demonstrate any abnormalities in the size, shape, or conformation of the milk ducts. As soon as lactation began, the bleeding stopped spontaneously, for repeated examination of aspirated milk was negative for red blood cells and subsequent mammograms were normal. It seemed incredible that trauma, infections, or neoplasms were the provocative agents and we assumed that an excessive vascularity incident to the functional hyperplasia of the lactiferous ducts was responsible for the bloody discharge.

Paget's disease of the nipple, tuberculosis, acute mastitis, vicarious menstruation, degenerating fibroadenoma, and sarcoma all have been reported as causing spontaneous, sanguineous, thelial discharges. One of the most unusual causes of such a bloody secretion was found in a woman, 78 years of age, who complained of a tumor mass in her breast.

iodides, akin to diodrast (Winthrop), which is used in intravenous pyelography, but the rapid diffusion is prevented by holding the soluble iodides in a suspension of viscous gum acacia. Aqueous solutions of iodides, such as hippuran (Mallinckrodt) and diodrast (Winthrop) cannot be used for visualizing breast tumors because of their high degree of diffusibility and rapid absorption. Skiodan viscous, on the other hand, remains within the lactiferous tubules from three to ten minutes, a sufficient time to permit accurate roentgenograms to be taken before it is absorbed. Thirty minutes after the ductal injections are made no skiodan viscous can be found within the ducts.

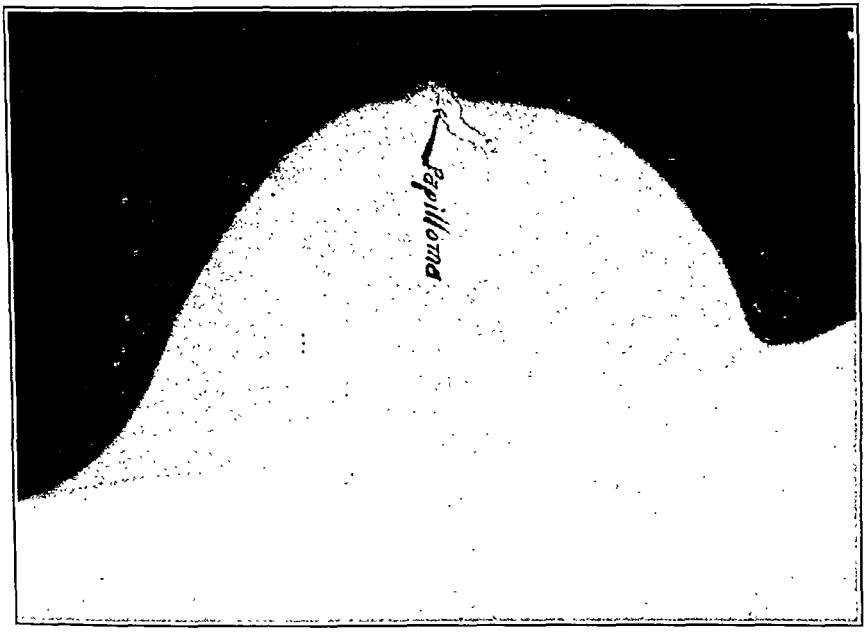


Fig. 4.—Papillomatous tumor visualized by skiodan viscous.

Fifty diagnostic mammograms using skiodan viscous have been made in virginal, lactating, resting, and diseased breasts without any untoward complications (Fig. 4). In five instances actively functioning breasts have been injected without diminishing the flow of milk or interfering with the regular periods of nursing. At the present time skiodan viscous is the most satisfactory visualizing agent we have studied. Its innocuous properties are attested by its extensive use in salpingography.

It is imperative that the patient be placed in the proper position on the roentgenologic table before the injection is made, for if five minutes elapse between the injection of the contrast substance and the time the mammograms are taken, a hazy, indefinite, and uninformative ductal pattern will be obtained. Much clearer detail can be obtained

order to facilitate the recognition of these tantalizing neoplasms, a new method of diagnosis has been developed. This procedure, termed mammography, was first described in 1937.[20] Accurate roentgenographic patterns of these intraductal tumors can be obtained by introducing contrast substances into the diseased lacteals. Any pathologic condition which alters the size, shape, or conformation of the ducts can be readily determined and accurately classified.

Due to the fact that papillomas are proliferating tumors which project into the ducts, they displace the contrast medium and produce characteristic filling defects. Papillomas measuring less than 1 mm. in diameter have been thus visualized and later found at operation.[21] Interestingly enough, four asymptomatic papillomas were visualized while making routine mammographic studies of patients with mazoplasia. In two other instances papillomas were found in both breasts, and on three occasions multiple lesions were found within the same gland.

Occasionally the contrast substance may not outline the offending papilloma, for the tumor may have completely occluded the duct or the resulting fibrosis may have closed the lumen. Obstruction of the lacteal sinuses in the presence of a patent orifice is indirect evidence of duct cancer or papilloma, particularly if there has been a sanguineous discharge from the nipple. In one instance, in which we were able to cannulate the bleeding duct but could not introduce the contrast medium, diathermy and hot applications to the breast were effective in opening up the duct so that the solution passed by the obstruction and clearly outlined the offending papilloma. Clinical experience indicates that mammographic studies are invaluable in recognizing and locating these evasive tumors.

In the earlier studies various radiopaque substances, such as lipiodine (Ciba), hippuran (Mallinckrodt), diodrast (Winthrop), and thorotrast (Heyden), were used. Thorotrast was found to be the most suitable because of its high radiopacity, low diffusibility, marked fluidity, and mild irritability to local tissues. Warning, however, was given that mammary abscesses would result from extraductal injections and likewise apprehension was expressed regarding the influence of the radioactive properties of thorotrast on the breast tissues.[20] In order to obviate these undesirable reactions, the thorotrast was removed by lavaging the ducts after the mammogram was taken. Such a procedure was effective but so tedious and laborious that it had to be abandoned. The subsequent work of Ries and Mesirow[29] and of Romonoff and McFetridge[30] indicated that thorotrast could produce granulomatous lesions; therefore, we have discontinued its use.

After extensive research and clinical investigation, it was found that skiodan viscous (Winthrop) was a suitable contrast substance for these mammographic injections. It is an aqueous solution of

iodides, akin to diodrast (Winthrop), which is used in intravenous pyelography, but the rapid diffusion is prevented by holding the soluble iodides in a suspension of viscous gum acacia. Aqueous solutions of iodides, such as hippuran (Mallinckrodt) and diodrast (Winthrop) cannot be used for visualizing breast tumors because of their high degree of diffusibility and rapid absorption. Skiodan viscous, on the other hand, remains within the lactiferous tubules from three to ten minutes, a sufficient time to permit accurate roentgenograms to be taken before it is absorbed. Thirty minutes after the ductal injections are made no skiodan viscous can be found within the ducts.

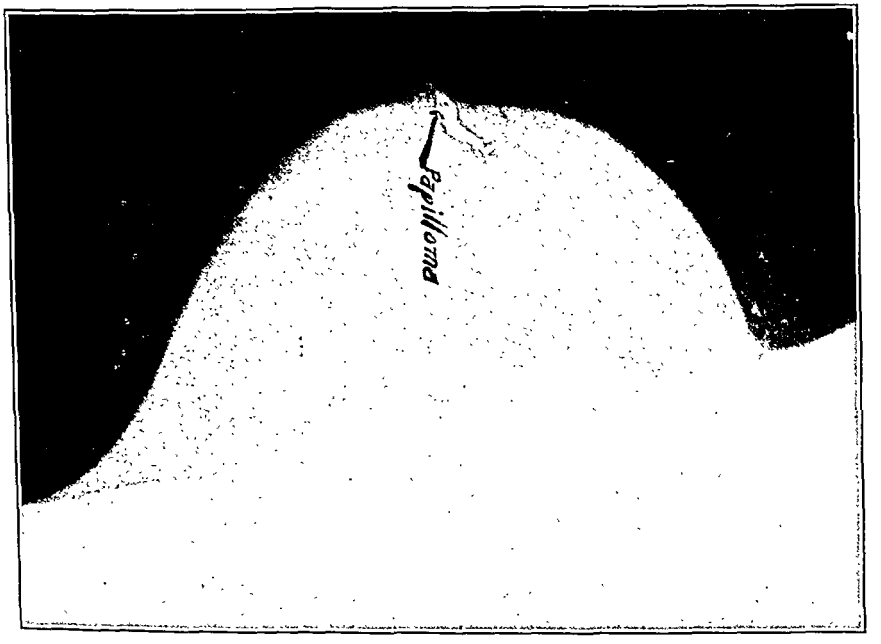


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with the Bucky diaphragm than with the cardboard holders. The technique of introducing the contrast substances into the ducts has been described elsewhere.

These mammographic studies are invaluable in recognizing and locating lesions which produce abnormal discharges from the nipples.[22] Chronic cystic mastitis, mazoplasia, papillomas, fibroadenomas, hemorrhagic infarcts, lactation hypertrophy, Paget's disease, galactoceles, and acute mastitis are some of the pathologic states which have been so recognized and diagnosed.[23]

Effective therapy is predicated on an appreciation of the morphologic characteristics and pathologic trends of these tumors. Recent articles have emphasized the innocent nature of these neoplasms and have strongly advocated such conservative treatment as local excision of the neoplasm. Babcock[3] has even devised a method of cannulating the offending lacteals so that the diseased segments can be removed by a simple plastic excision. While such conservatism is to be desired, we sincerely believe it to be inimical to the patient's best interests.

In the first place, careful studies have clearly demonstrated that papillomatous lesions are usually multiple and not single solitary growths. In the majority of our cases, serial sections have demonstrated intraductal epithelial proliferation in other lacteal sinuses than the one harboring the bleeding papilloma. Local excision of the bleeding duct still affords an opportunity for the others to develop. Recurrence following local extirpation of the offending papilloma is much more common than is usually appreciated. Adair[1] found that 15 per cent of the cases treated by removal of the tumor alone later developed a bloody discharge from the same or the opposite mammary gland. Geschickter,[15] who classifies papillomas as benign lesions, reported 65 patients treated by local excision of the tumors, and of these 6 had definite recurrences, some requiring as many as two and three operations. Bowlby,[4] Morton,[27] Williams,[37] Greenough and Simmons,[17] Labbe and Coyne,[25] Pollard,[28] and Deaver and McFarland[10] all report recurrences or the formation of new papillomas following local excision of the primary tumor. Such a high percentage of recurrences combined with the tendency of papillomas to be multiple seems a strong argument for a simple mastectomy.

Secondly, the pernicious tendency of papillomas to undergo malignant changes strongly suggests the inadequacy of conservative therapy. Stowers[33] believes that a simple mastectomy is the method of choice in dealing with these treacherous lesions for he encountered a small asymptomatic carcinoma lying in a distant part of a breast he had removed because of a bleeding papilloma. In one instance, we inadvertently discovered a papillary adenocarcinoma in a breast which had been removed because of a bloody discharge from the nipple. Had the offending tumor merely been excised, the carcinoma would have been left behind to grow and metastasize. Adair[1] reports a similar

case, for he removed a papilloma measuring but 7 mm. in diameter, and one year later the patient returned with an infiltrating carcinoma. Did this cancer develop as an entirely independent tumor, or did it evolve from a papilloma which had been overlooked? A mastectomy would certainly have prevented this catastrophe.

Third, if radical mastectomies are reserved only for those cases in which the parent tumor, after excision, is found to be malignant, many cases of cancer will be overlooked. In many instances the carcinomatous process may be lurking in some other segment of the breast and may not be detected by examination of one papilloma. The multiplicity of these tumors renders biopsies ineffectual, as frequently it is the small asymptomatic papilloma which shows the sinister changes of carcinoma. It seems more rational to employ simple mastectomies in all cases of papillomatous tumors and to utilize the radical procedures for those that are definitely known to be malignant. Certainty is assured only after painstaking study of the entire breast.

It is true that we do not wish to be stampeded into the wholesale removal of breasts and mastectomies should be employed only in those cases in which the diagnosis is certain. Mammographic visualization studies remove the doubt and uncertainty which formerly accompanied the diagnosis of these intraductal neoplasms, for they portray the identifying characteristics of papillomas of the milk ducts with the same degree of accuracy that x-rays of the stomach, colon, or genitourinary tract portray similar lesions in those organs. All it requires is perseverance and experience.

CONCLUSIONS

1. In their early cycle of development papillomas of the breast are essentially benign lesions, but, if left alone, they have a pernicious tendency to undergo malignant transition.

2. Serial studies of fifteen breasts indicate that these papillomatous lesions are generally multiple, often bilateral, and occasionally associated with other pathologic changes, such as mazoplasia, cystic degeneration, fibroadenomas, and even distinct carcinomas.

3. A bloody discharge from the nipple is not pathognomonic of intracystic papillomas of the breast but may occur with Paget's disease, duct cancer, adenocarcinoma, chronic cystic mastitis, gestational hypertrophy, trauma, and acute mastitis.

4. Papillomas of the breast can be easily recognized and accurately located by means of mammographic visualization studies.

5. Recurrences may follow the simple excision of a papilloma.

6. A simple mastectomy is the ideal form of therapy for the benign papilloma.

7. Radical operations and irradiation therapy should be reserved for those cases which are definitely malignant.

8. Every papillomatous lesion should be studied in its entirety for malignant changes before it is pronounced benign.

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SURGICAL TREATMENT OF ROENTGEN AND RADIUM DERMATITIS

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THE length of time at present necessary for the determatologic and surgical treatment of roentgen dermatitis accounts for the fact that a number of patients are under treatment most of the time. Obviously many patients with such dermatitis have no great trouble. Many other patients have mild itching, telangiectasia, pigmentation and atrophy of the skin and its appendages for which various types of dermatologic care are adequate. However, in the presence of indurated, boardlike skin with recurring ulcerations, pain, deformity, and loss of function due to contraction of the skin and underlying fascial layers, it is necessary to control the symptoms by removal of the lesion rather than to temporize with it. Particularly is this so if the chronic ulceration persists or scar forms in the presence, or possible presence, of malignancy. There may be said to be two types of radium and roentgen dermatitis, the acute and chronic forms. The acute form at times may be very troublesome and may not respond to the usual types of conservative treatment demanding surgical excision and plastic procedure. At times, in the more acute forms the surgical treatment may be disappointing because of the fact that one may not recognize the margins of the damaged tissue and excision may not be wide enough. Fortunately, these more acute types are not so frequently seen and the difficulties of treatment of this type of case are not so often encountered. The chronic type may present itself at almost any time following original injury.

Although we are interested in the cosmetic result of any plastic procedure, our concern has been more often with relief of pain, healing of ulceration, avoidance or eradication of malignant tissue. Hence, this review has been undertaken to determine what results can be expected from surgical treatment by excision and grafting. The records of patients with roentgen dermatitis of the trunk and extremities treated surgically in the Mayo Clinic between 1928 and 1937, inclusive, have been reviewed and the data tabulated.

MATERIAL

In this series of 97 patients were 53 males and 44 females. They varied in age from 3 to 72 years. The distribution, in the main by decades of life, is given in Table I.

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Received for publication, October 18, 1939.

TABLE I

AGES OF PATIENTS

AGE (YR.)	PATIENTS
1 to 20	4
21 to 30	14
31 to 40	21
41 to 50	20
51 to 60	29
61 to 72	9
Total	97

Patients have difficulty, after an interval of many years, in remembering the nature of a lesion for which roentgen or radium therapy was used. However, in a large percentage of the cases in this series the history was accurate as to the original lesion; either the patient described his symptoms well or the presence of lesions confirmed the original diagnosis. The original conditions which were exposed to radium or roentgen rays were as follows: eczema, 21 cases; hands of roentgenoscopists, 11; indeterminate condition and tumors of the breast, 7 each; trichophytosis, "warts," and callus, 4 each; carcinoma of uterus and cervix, foreign body (roentgenoscopic removal), vascular nevi, and pigmented nevi, 3 each; indeterminate abdominal pain, giant cell tumor, hypertrichosis, epithelioma (?), "irritated skin," psoriasis, and trauma, 2 each; and ulcer plus scrubbing, fibromyoma of uterus, pruritus ani, angioma of leg and sacrum, nodule of axilla, metrorrhagia and mastitis, keloid, "lumps" in epigastrium, sacral tumor, tumor of hip, acne, gastric ulcer (diagnostic roentgenography), and ulcer of the hand, 1 each.

The anatomic situations of the lesions were as follows: thumb and fingers, 16 cases; hand (dorsum), 16; hand (palm), 4; hand (dorsum of both), 3; foot (sole), 7; foot (dorsum), 4; leg, 8; abdomen, 7; breast, 6; arm, 3; thigh, knee, axilla, chest, sacrum, hip and sacrum, 2 each; and shoulder, hip, popliteal space, toes, back sacroiliac region, scrotum, groin, perineum, both legs, abdominal wall, and sacroiliac region, 1 each. The high incidence of actinodermatitis of the fingers and hands was due, in part, to the greater frequency of occupational roentgen dermatitis among members of the medical and dental professions. Nineteen of the patients were physicians or dentists. Among laymen, the relative frequency of roentgen dermatitis about the hands was accounted for by the frequency with which various types of eczema of the hands are treated by roentgen rays. Dermatologic conditions predominate among the reasons for which the original roentgen or radium therapy was given. In those cases in which roentgen dermatitis followed treatment of a malignant condition, treatment was by radium or radium supplemented by roentgen rays for the most part. Roentgen dermatitis of the sacrum, buttocks, back, and abdomen usually followed radium or roentgen therapy of malignant tumors of the abdomen or prolonged diagnostic procedures applied to the gastrointestinal tract. Considering the in-

cidence of genital and anal pruritus among members of the general population, the incidence of roentgen dermatitis of these regions, necessitating surgical relief, was unusually low.

Of this series of 97 patients, 9 had received radium therapy only; 70 patients, roentgen therapy only; and 18 patients, both radium and roentgen therapy. While in a fair percentage of the cases the number of treatments given was known, the technical factors were in most instances unknown and thus an estimate of the dosage effective in the production of the various lesions noted was difficult to make.

An estimate of the interval between the first treatment with roentgen rays or radium and the application of surgical treatment at the Mayo Clinic is as follows: six months or less, 6 cases; one year (and more than six months), 14; two years, 9; three years, 4; four years, 5; five years, 2; six years, 8; seven years, 9; eight, nine, and ten years, 2 each; eleven years, 3; twelve, thirteen, and fourteen years, again 2 each; fifteen years, 3; eighteen years, 5; nineteen, twenty, twenty-four, twenty-nine, thirty, thirty-four, and thirty-seven years, 1 each; and unknown, 10. Obviously, this is not an estimate of the time between the first exposure and the development of necrosis or of any of the other indications for surgical measures, but it does indicate that those patients who have lesions for which surgical operation will be necessary will come to operation within seven years of the time of their first exposure in the great majority of instances. In many instances the diagnosis of roentgen dermatitis had been made at the clinic or elsewhere a year or more before surgical treatment was adopted and in some cases the patients had known that they had dermatitis for many years before they sought surgical relief. Some of these patients had undergone various types of surgical treatment before they came to the clinic.

The results of histopathologic examination of the tissue removed were recorded. In 20, or 20.6 per cent, of the cases squamous-cell epithelioma of the skin had developed in the area of roentgen dermatitis. All but 2 of these 20 cases, Cases 30 and 31, are recorded in subsequent tables. In Case 30 the epithelioma was of malignancy Grade 1 and was situated on the abdominal wall. The epithelioma in Case 31, also of Grade 1, was found on a finger of the left hand; the index, middle, and ring fingers of this hand were the site of many lesions of keratosis. In 3 other cases (Cases 38, 53, and 88) malignancy of the epitheliomas also was of Grade 1. The epitheliomas in 6 of the 20 cases (Cases 45, 73, 77, 84, 89, and 90) were of Grade 2. The grade of malignancy of the epitheliomas was 3 in 8 cases (Cases 40, 46, 63, 75, 78, 81, 82, and 83) and only in Case 74 was the epithelioma of Grade 4. In 7 other cases roentgen dermatitis was superimposed on a previously existing malignant condition, such as carcinoma of the breast or a connective tissue tumor of the extremities. Simple ulcer was present in 7 instances, chronic in-

flammation in 3, and hyperkeratosis in 3. In 57 instances a tissue diagnosis of roentgen dermatitis was made, usually under such terms as "subepithelial inflammation with fibrosis," "chronic inflammatory tissue with fibrosis associated with epithelial hyperplasia," and "keratosis." These terms stated briefly the pathologic picture described by Wolbach and others to indicate changes the result of injury by roentgen rays or radium. A specimen was not available for examination in 7 instances. It is of considerable interest that of the 39 cases in which roentgen dermatitis of the hands was present in 16 (41 per cent) the condition was malignant (squamous-cell epithelioma).

In the series of 97 cases there was 1 fatality from malignancy which developed on the basis of roentgen dermatitis.

CASE REPORT.—The patient was a man, 52 years of age, who first registered at the clinic on Jan. 4, 1932. For three years previous to his first visit to the clinic he had been receiving weekly roentgen-ray and ultraviolet irradiation for trichophytosis affecting the inner side of the sole of the right foot and extending onto the internal malleolus. Excision was performed and a full thickness skin graft was applied Jan. 26, 1932, for a lesion which proved, on microscopic examination, to be a squamous-cell epithelioma, Grade 2, associated with leucoplakia, subepithelial inflammation, and fibrosis. Healing was delayed, although most of the graft "took." Pinch grafts were applied to an area over the inner aspect of the right ankle on Nov. 8, 1932, and ulcers over the right internal malleolus and right heel were cauterized on Jan. 13, 1934. Complete healing failed to take place at any time and, on Jan. 29, 1937, the patient returned to the clinic for biopsy of lymph nodes of the right groin and of the ulcer over the foot. In both of these regions malignancy, Grade 3, was found on microscopic examination. The patient died from hemorrhage from an artery in the right groin on Aug. 14, 1937.

As in the series reported by Saunders and Montgomery, doubtless a higher mortality would have developed if the patients had been followed over a longer period.

GENERAL CONSIDERATION OF TREATMENT

The following résumé of skin grafting as applied to the surgical management of roentgen dermatitis follows closely the writings of Blair and Brown, of Gillies and McIndoe, and of Porter. The work of these men is fundamental in the surgical management of these lesions.

The type of graft best suited for the loss, the speed of the operation, the source of the graft, and the healing powers of the patient all have bearing on the type of graft selected in each case. A full thickness graft is appropriate for a freshly made raw surface, without infection, where substantial protection, maximal mobility, minimal subsequent contraction, and the most natural appearance are essential. They are usually chosen to cover a contracted, healed surface in which the full thickness of the scar must be cut through or removed to allow relaxation. In the present group of cases, small areas about the feet, about the small joints of the hands, and about the dorsum of the hands seemed to be the fields of usefulness for the full thickness skin graft. For fresh granu-

lating surfaces, on surfaces that will resist subsequent contraction, if the appearance and demands of function do not contraindicate their use, thinner grafts are chosen because of the simplicity of their application and the greater certainty of a take. Particularly are these grafts useful on the back of the hand and over extensive defects of the trunk (back, chest, and abdomen). The technique of application of the full thickness graft and its aftercare are exacting and time-consuming. The graft is susceptible to infection so that the patient must possess good healing powers.

Three factors may seriously affect the final result when the thinner, split skin graft is employed: (1) The thinner graft may not give sufficient protection to a bearing surface. (2) It will not correct the inequalities of the underlying surface. (3) If placed on a freshly made raw surface, and if the recipient region has a movable base and movable edges, subsequently the graft contracts without any loss of epithelium. Contraction takes place in the scar tissue of the bed and not in the graft itself. The true Ollier-Thiersch graft is supposed to include little more than the epithelial layer. If the graft is cut so as to include an appreciable thickness of the dermis, it seems to possess more of the good than of the bad points of either the full-thickness or the true Ollier-Thiersch graft. If the host's resistance is low, grafting of any kind should be deferred. Almost all failures are attributable to infection. Success or failure in the use of grafts will depend more on the healing qualities of the tissues than on all other factors combined. This is especially significant when the poor blood supply to the tissues immediately beneath an area of roentgen dermatitis is considered.

As Gillies and McIndoe pointed out, in using split skin grafts the immediate result may be disappointing, due to wrinkling, depression, and hardness of the graft, but later the graft will become smooth and filled out. Gillies and McIndoe did not recommend the use of full-thickness grafts because of the high standard of technique required for success with them and the tendency that exists to trophic changes in the graft.

It may be necessary to delay operating on the lesions that are under consideration here to avoid the disappointment of poor healing of tissue. The older lesions that have been scarred over for a number of years are not especially bothersome in this respect, as a relatively long period has been allowed for development of a new blood supply in the tissues immediately beneath the scar of roentgen dermatitis. More difficulties are encountered in preoperative clearing up of ulceration that persists in spite of all forms of treatment and undergoes neither healing nor frank sloughing. Special preoperative care of infection in areas of roentgen dermatitis will lessen the risk of failure. This care includes frequent changing for a few days of packs soaked in mild antiseptic or hypertonic salt solution until active suppuration has come under control.

flammation in 3, and hyperkeratosis in 3. In 57 instances a tissue diagnosis of roentgen dermatitis was made, usually under such terms as "subepithelial inflammation with fibrosis," "chronic inflammatory tissue with fibrosis associated with epithelial hyperplasia," and "keratosis." These terms stated briefly the pathologic picture described by Wolbach and others to indicate changes the result of injury by roentgen rays or radium. A specimen was not available for examination in 7 instances. It is of considerable interest that of the 39 cases in which roentgen dermatitis of the hands was present in 16 (41 per cent) the condition was malignant (squamous-cell epithelioma).

In the series of 97 cases there was 1 fatality from malignancy which developed on the basis of roentgen dermatitis.

CASE REPORT.—The patient was a man, 52 years of age, who first registered at the clinic on Jan. 4, 1932. For three years previous to his first visit to the clinic he had been receiving weekly roentgen-ray and ultraviolet irradiation for trichophytosis affecting the inner side of the sole of the right foot and extending onto the internal malleolus. Excision was performed and a full thickness skin graft was applied Jan. 26, 1932, for a lesion which proved, on microscopic examination, to be a squamous-cell epithelioma, Grade 2, associated with leucoplakia, subepithelial inflammation, and fibrosis. Healing was delayed, although most of the graft "took." Pinch grafts were applied to an area over the inner aspect of the right ankle on Nov. 8, 1932, and ulcers over the right internal malleolus and right heel were cauterized on Jan. 13, 1934. Complete healing failed to take place at any time and, on Jan. 29, 1937, the patient returned to the clinic for biopsy of lymph nodes of the right groin and of the ulcer over the foot. In both of these regions malignancy, Grade 3, was found on microscopic examination. The patient died from hemorrhage from an artery in the right groin on Aug. 14, 1937.

As in the series reported by Saunders and Montgomery, doubtless a higher mortality would have developed if the patients had been followed over a longer period.

GENERAL CONSIDERATION OF TREATMENT

The following résumé of skin grafting as applied to the surgical management of roentgen dermatitis follows closely the writings of Blair and Brown, of Gillies and McIndoe, and of Porter. The work of these men is fundamental in the surgical management of these lesions.

The type of graft best suited for the loss, the speed of the operation, the source of the graft, and the healing powers of the patient all have bearing on the type of graft selected in each case. A full thickness graft is appropriate for a freshly made raw surface, without infection, where substantial protection, maximal mobility, minimal subsequent contraction, and the most natural appearance are essential. They are usually chosen to cover a contracted, healed surface in which the full thickness of the scar must be cut through or removed to allow relaxation. In the present group of cases, small areas about the feet, about the small joints of the hands, and about the dorsum of the hands seemed to be the fields of usefulness for the full thickness skin graft. For fresh granu-

use of split-skin grafts were the trunk and proximal portions of the extremities and the dorsal surfaces of the hands and feet. The grafts usually were removed, after the method of Blair and Brown, from the anterior surfaces of the thighs and transferred directly to the cleaned, granulating surfaces where they were required or, in many instances, to

TABLE II

SPLIT-SKIN GRAFT

CASE	SITUATION OF LESION	RESULT	OTHER PROCEDURES	COMMENT
33	Dorsum right hand	Success	None	
34	Sacrum	Success	None	Unable to follow patient
35	Epigastrium	Success	None	
36	Dorsum right thenar web	Success	Previous pedicle graft failed	Patient followed 2 yr.
37	Left palm	Success	None	
38	Dorsum right hand	Success	None	Stiffness of fingers 2 yr. later; sq. cell ep.* Grade I
39	Chest wall	Success	None	Slow to heal
40	Left index	Success	Subsequent prophylactic amputation of finger	Sq. cell ep. Grade 3; no recurrence in 1 yr.
41	Dorsum left hand	Success	None	Stiffness of hand; slow to heal
42	Sacrum	Success	None	Extensive sloughing had followed biopsy elsewhere
43	Sole right foot	Success	None	
44	Epigastrium	Success	None	
45	Left index	Success	None	Sq. cell ep. Grade 2 in situ; keratosis 1 yr. later
46	Chest wall	Success	None	Sq. cell ep. Grade 3; no recurrence in 1 yr.
47	Sacrum	Success	Previous pedicle to outer side left knee	Extensive hemangioma leg, thigh, buttock
48	Right knee	Success	None	Malignant giant-cell tumor destroyed by roentgen therapy
49	Sacrum	Success	None	Patient followed 2 yr.
50	Abdominal wall	Success	Partial closure	Patient followed 8 yr.
51	Left groin	Success	Previous pedicle graft only partly successful	Patient followed 7 yr.
52	Right leg	Failure	Five years later full thickness graft to right shin succeeded	Patient followed 6 yr. after last procedure
	Left calf	Success		
53	Right thenar eminence	Success	Subsequently epitrochlear gland excised (inflammatory)	Sq. cell ep. Grade 1
54	Left leg	Failure	Necessary to reapply split skin graft	
55	Dorsum left foot	Success	Previous pedicle graft failed	Healing delayed
56	Dorsum right hand	Success	None	Small area slow to heal
30†	Abdominal wall	Success	Previous (1922) excision and closure; pinch grafts to close present defect	Sq. cell ep. Grade 1 (1933); large hernia developed in wound

*In this and subsequent tables *sq. cell ep.* signifies squamous-cell epithelioma.

†This is one of the 32 cases in which excision was performed. Since split-skin graft also was employed, the case appears in this table.

Most epitheliomas require excision down to the fascia and immediate grafting, but, for those which are extensive or which have been neglected, amputation and dissection of regional lymph nodes are required. Lesions of the sole of the foot can be repaired with a free graft if a deep, healed scar is not present. However, a deep lesion, entailing loss of the pad of fat, may be best treated by transfer of a flap carrying both the skin and the subcutaneous fat. As Gillies and McIndoe pointed out, the distinguishing feature of chronic roentgen dermatitis is that the superficial tissue of the whole area can be dissected up from the subjacent tissues with ease for there is a marked plane of cleavage between normal and devitalized structures.

TREATMENT IN PRESENT SERIES

In the 97 cases a variety of procedures was performed. They were identified as follows: excision, split-skin graft (Table II), pedicle graft (Table III), amputation (Table IV), full-thickness graft (Table V), pinch graft (Table VI), and biopsy only. When the study was in progress, each case in which one of these procedures was employed was tabulated under its respective heading and, since in several cases more than one procedure was used, each such case was represented under more than one heading. For publication, however, it seemed unnecessary to include the table which dealt with excision. This operation was performed in 32 cases. Table II, therefore, wherein are recorded the cases in which split-skin grafts were employed, begins with Case 33 and cases lower in the series (Cases 2, 3, and 30) appear in the tables only in those instances in which some procedure was employed in addition to excision. Also, it seemed unnecessary to publish the table concerning the cases in which biopsy only was performed. There were two such cases (Cases 96 and 97) in the entire series of 97 cases. In neither of these was any other procedure used. In the published tables, therefore, the highest case number to appear is Case 95.

Excision.—Excision or excision and primary closure was performed 32 times for lesions on all parts of the body, and in general the results were satisfactory. Many of these lesions were small and were in situations where the integument was especially mobile so that few technical difficulties were presented. Further discussion of these cases will not be presented as the indications, operative procedures, and aftercare are obviously so variable that little of consequence can be derived from further study of them.

Split-Skin Graft.—The split-skin graft, as described in the various papers of Blair and Brown, was used 25 times with 2 failures (Table II). It is apparent that this form of plastic repair will find many fields of usefulness in restoration of defects caused by excision for roentgen dermatitis involving relatively large areas. The regions favored for the

slough, but the approximation of edges will be much closer than if any other method of apposition is employed.

Various types of dressings have been tried with varying success. The important feature to attain is absolute fixation of the graft with pressure in order that none of it may become elevated and slough away. Use of sea sponge as part of the dressing helps maintain the pressure. In many cases in which the hands are the site of the injury, it is imperative to immobilize the wrist and fingers by means of previously constructed splints for a period varying from two to three weeks, or until physical therapeutic measures can be safely started, the time depending on the degree to which the superficial tissues close in over any areas that have not been completely covered by the graft.

Provided the donor tissues have been secured in the manner described by Blair and Brown, a covering of petrolatum gauze or scarlet red-ointment gauze is applied over the donor area and its use is continued for from ten days to two weeks. Usually, at the end of this time the dressing need be left in place no longer. Healing is rapid and within a few months a fine pebbling of the skin is all that is left in the donor area to indicate that tissue has been removed. The area where the graft has been applied is not dressed until the sixth or seventh day, provided there is no indication for applying a dressing, such as excessive pain, foul odor, or elevation of the patient's temperature. The superficial layers of some parts of the graft usually slough. The overlapping edges of the graft do slough and can be cut away. Stitches are removed on the tenth or fourteenth day and the area of the graft on each occasion is dressed again with scarlet red-ointment gauze. The sea sponge is reapplied; from its first application when wet, the sponge assumes the shape of a mold of the part affected and in many instances serves as an excellent splint. Provided all areas have been covered with graft, complete healing usually will take place in from three to five weeks, although in some instances the healing about the edges of the normal skin will be slow or a central area of poor subcuticular nutrition may lead to slow healing in the central area of an excised portion of tissue that is the site of roentgen dermatitis. It has been our experience that, if wide excision has been done, healing ultimately results in spite of a partial "take" of the graft.

Various Procedures Based on the Principle of the Pedicle Graft.—Pedicle grafts of various types were employed 19 times with 4 failures, or 21 per cent (Table III). In 3 of the 4 cases in which the results were failures, split skin grafts subsequently were completely successful and satisfactory as to coverage of the defect, although mobility and pliability of the part were somewhat sacrificed. The fourth graft to fail was placed on the dorsum of a hand in which the tendons were exposed at the time of operation. This patient was being prepared for further grafting followed by tendon repair but failed to respond to letters of in-

the raw surface made by excision of tissue in an area of roentgen dermatitis (Fig. 1*A* and *B*). It is customary at the Mayo Clinic to apply the graft to a field that is perfectly dry, to baste it down with multiple strands of silk or horsehair, and to puncture the graft in



Fig. 1.—Hands of a man aged 66 years. *A*, Roentgen dermatitis of twenty years' duration and dermatitis on dorsal surfaces of both hands; *B*, two months after excision and application of split-skin graft to right hand.

numerous places to permit egress of serum and to promote direct contact of the graft with the underlying raw surface. The edges of the grafts are overlapped; also, they are made to overlap the edges of the area which it is desired to cover. The overlapped portions of graft will

slough, but the approximation of edges will be much closer than if any other method of apposition is employed.

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TABLE III

PEDICLE GRAFTS

CASE	SITUATION OF LESION	RESULT	OTHER PROCEDURES	COMMENT
57	Dorsum left foot	Success	Previous amputation three lateral toes	Donor area right leg necessitated pedicle
58	Interscapular region	Success	None	graft from right thigh
59	Dorsum right hand	Failure	None	Graft from adjacent area on back
60	Palm left hand	Success	Supplementary pinch grafts 8 mo. later	Tendons sloughed following failure of graft
61	Left ankle	Success	None	
62	Sole right foot	Success	None	
63	Right leg	Success	Treatment for some months to infected edge of graft	Sq. cell ep. Grade 3; graft successful
64	Sole left foot	Success	None	
65	Right thenar web	Success	None	Occasional infection hair follicle in graft
66	Dorsum left hand	Success	None	
67	Dorsum right hand	Success	Subsequent capsulotomy metacarpophalangeal joints, index, middle, ring, and fifth fingers	Stiffness hand and fingers
68	Dorsum right hand	Success	Subsequent fashioning of webs of fingers, elsewhere	Abdominal pedicle
69	Palm right hand	Success	None	Sleeve graft from the back; graft over thenar web failed; some stiffness of fingers reported 10 yr. later
70	Left heel	Success	None	
71	Dorsum left hand and fingers	Success	None	Unable to follow patient
36*	Dorsum right thenar web	Failure	Split-skin grafts eventually successful	
47*	Left knee	Success	Split-skin graft to sacrum three years later	Patient pulled off pedicle graft Extensive hemangioma left leg, thigh, buttock
51*	Left groin	Failure	Split-skin grafts one month later	Complete healing for 7 yr.
55*	Dorsum left foot	Failure	Subsequent split-skin graft successful	Eventual result satisfactory

*Since split-skin graft and pedicle graft both were employed in this case, the case is represented both in Table II and in this table.

quiry. Fifteen, or 79 per cent, of this series of 19 grafts were successful (Fig. 2*A* and *B*). In several of the cases, however, subsequent or concomitant procedures were necessary, in addition to those of shaping and spreading the graft on the defect. Pinch grafts were necessary to fill in a defect once. One patient required treatment of the infected edge of a graft for several months. Only one pedicle graft was used following removal of a malignant growth.

Defects of the dorsum of the hand, including the thenar web in one case, were covered 7 times with delayed or sleeve grafts, the dorsum

of the foot twice and the ankle once; the sole of the foot and the palm of the hand each was thus covered twice and the heel once. The knee, the leg, the groin, the interscapular region, each was the site of various types of pedicle grafts. Failures were as follows: 2 referable to the dorsum of the hand, 1 in which application was over the dorsum of the foot, and 1 attempt to apply a graft to a lesion in the groin.

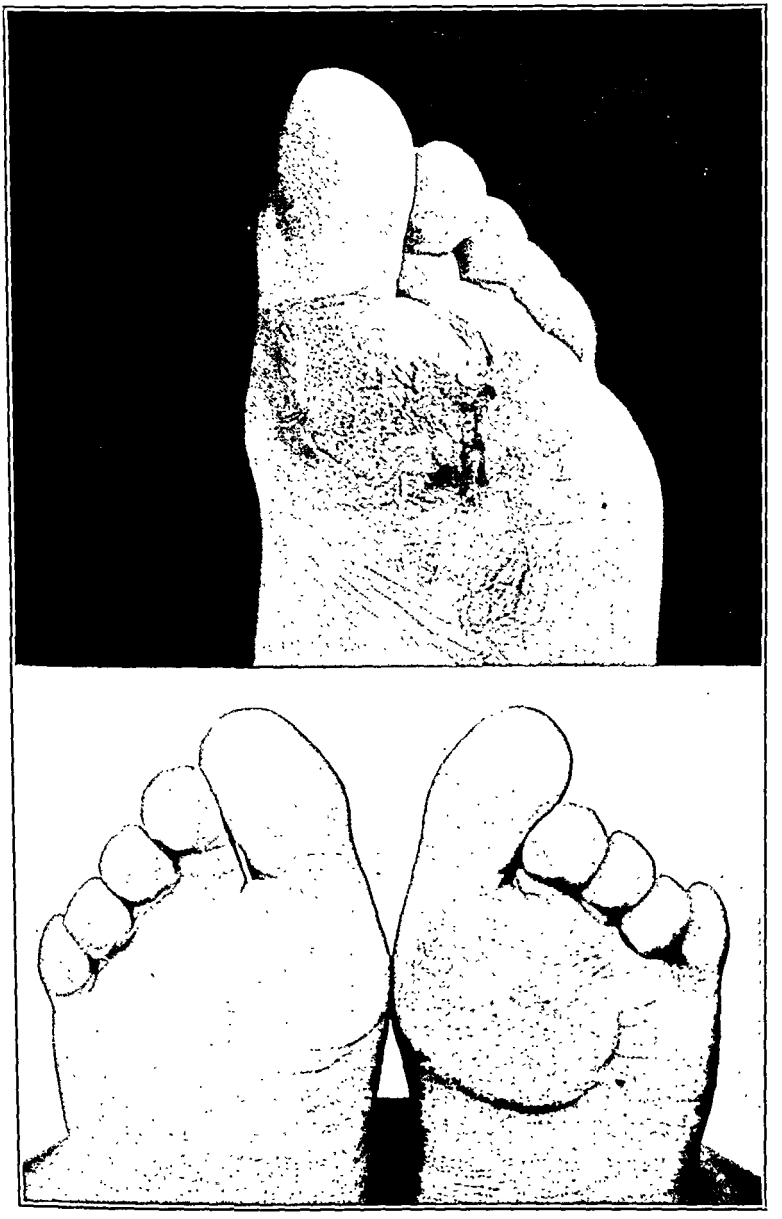


Fig. 2.—Feet of a woman aged 27 years. *A*, At time of admission; roentgen dermatitis following treatment for plantar warts two years before; *B*, following completion of excision and pedicle graft to repair defect.

The delayed type of flap was used almost entirely. Those for the hands were from the abdomen and those for the legs, ankles, and feet from the opposite thigh or leg. The areas desired for flaps were outlined; the flaps were raised and sutured twice within ten days and were transferred at the end of eighteen days to three weeks. Following the second elevation of the delayed flap, split skin grafts taken from the thigh were placed beneath the delayed flap corresponding with an area which it was estimated would not be covered by the pedicle following severance of the flap. The legs were retained in plaster of Paris casts until the pedicle had been cut through, usually a matter of another three weeks. The donor area usually was well healed by the time the area on which the graft was to be placed had been refashioned and the graft flattened and made pliable.

Sleeve grafts of a double pedicle raised from the abdomen, back, or thigh are applicable to large defects of the dorsum of the hand, including the fingers, while single pedicle delayed flaps are useful in treatment of smaller lesions, especially of the palm and thenar web, or the dorsum of the metacarpophalangeal joints. The advantages of the delayed pedicle graft in repair of defects of the hands and feet are those of pliability and better weight-bearing surface. The disadvantages are a relatively long residence in hospital and multiple operations. The disadvantages are important if patients are elderly or if economic welfare of the patient is prominent among the considerations.

A sliding graft was used but once to repair a defect on the back, between the scapulae. Tubed grafts were not employed. Grafts by successive migration are almost never necessary when dealing with defects about the extremities.

Amputation.—Amputations were performed in 15 cases and in 2 of these subsequent amputations also were carried out (Table IV). There were 2 amputations of the toes, 2 through the thigh, and 11 of the fingers; we are speaking of the number of operations, not of the number of members removed, for in several instances more than one member was removed at one operation. Seven of the amputations were performed for squamous-cell epithelioma on the basis of complicated roentgen dermatitis, while 1 amputation was done through the middle of the thigh for a fibrosarcoma about the knee. The other amputation through the middle of the thigh was done for intractable painful roentgen dermatitis following extensive irradiation of a giant-cell tumor of the upper end of the fibula. Conservative measures had been carried out over a period of a year without benefit.

Subsequent procedures or procedures carried out simultaneously with amputation usually consisted of further amputations of other digits, as necessity demanded in view of the development of malignancy. Subsequent and concomitant skin grafting was carried out in 2 cases.

TABLE IV

AMPUTATIONS

CASE	SITUATION OF LESION	OTHER PROCEDURES	COMMENT
72	Right thigh	None	Had been treated medically for 1 yr. with excision of several sloughs; lesion resulted from roentgen destruction giant-cell tumor of fibula
73	Left ring finger	Right index, middle, and ring fingers 2½ yr. later and right fifth finger 4 yr. later	Alive and well 5 yr. after first amputation; all were done for sq. cell ep. Grade 2 of left ring finger, Grade 4 of right index middle and ring fingers, Grade 2 of right fifth finger
74	Left thumb (through first phalanx)	Dissection of axillary nodes (inflammatory) a few days later	No recurrence 7 yr. later; done for sq. cell ep. Grade 4
75	Right thumb and ulcerating stump right index finger (block excision including first and second metacarpal and multiangular)	Recurrence excised 2 mo. later	Sq. cell ep. Grade 3 with early recurrence in stump
76	Second, third, and portion great toe and fourth toenail of left foot	None	Complete recovery; no difficulty in walking
77	Right middle finger	Excision area right fifth finger and several keratoses 1 yr. later	Sq. cell ep. Grade 2 right middle finger; sq. cell ep. in situ right fifth finger; sq. cell ep., Grade 1 in base of keratoses, finger not specified
78	Left ring finger	Subsequent excision nail left middle finger; amputation (elsewhere) distal phalanx right middle finger	Sq. cell ep. Grade 3, left ring finger; apparently no recurrence in 4 yr.
79	Right knee (through thigh)	Previous excision of ulcers	Original lesion a fibrosarcoma Grade 3; died in 2 yr.
80	Right ring finger		Good result; patient followed 8 yr.
81	Left middle finger		Sq. cell ep. Grade 3; no recurrence in 2 yr.
82	Left middle finger	15 yr. later, excision and pinch grafts for ulcer base left index finger, site of sq. cell ep. Grade 3	Good result
83	Left middle and ring fingers; right index and middle fingers	None	Sq. cell ep. Grade 3, right middle nails of right index and ring fingers and distal phalanx of middle finger removed
2*	Right index, distal phalanx	None	Good result; patient followed 6 yr.
3*	Right ring finger	None	Good result; patient followed 8 yr.
57†	Three lateral toes left foot	Subsequent pedicle graft dorsum left foot	Good result; donor area on right leg required graft

*This is one of the 32 cases in which excision was performed. Since amputation also was done, the case appears in this table.

†Since pedicle graft and amputation both were employed in this case, the case is represented both in Table III and in this table.

Relatively conservative amputations are possible for squamous-cell carcinomas which result from complicated roentgen dermatitis because spread of the lesion is rare and metastasis late. Axillary dissection was performed in 1 case of a squamous-cell epithelioma Grade 4 of the left thumb and the nodes gave evidence of inflammatory reaction.

Full-Thickness Graft.—Full-thickness grafts were performed 8 times with 3 failures, or 37 per cent (Table V). Full-thickness grafts are

TABLE V

FULL-THICKNESS GRAFT

CASE	SITUATION OF LESION	RESULT	OTHER PROCEDURES	COMMENT
84	Sole right foot	Failure	Pinch grafts 10 mo. and biopsy 5 yr. later	First lesion sq. cell ep. Grade 2, 5 yr. later, lesion Grade 3, with metastasis in groin; patient died hemorrhage artery in groin; foot never healed
85	Sole right foot	Success	Supplementary pinch grafts 4 mo. later	
86	Left palm	Success	None	Extensive keratosis both hands 7 yr. later
87	Dorsum both hands	Failure	None	Only 50 per cent successful on the right side
88	Left ring finger	Success	None	Sq. cell ep. Grade 1 in situ; good result from graft
89	Dorsum left hand	Failure	Later pinch grafts partly successful (also right index)	Sq. cell ep. Grade 2; some residual stiffness
90	Dorsum right hand	Success	None	Sq. cell ep. Grade 2; patient followed 6 yr.
52*	Right leg	Success	Split skin graft 5 yr. previously failed	Patient followed 6 yr.

*Since split-skin graft and full-thickness graft both were employed in this case, the case is represented both in Table II and in this table.

particularly applicable when a considerable amount of material has been removed as the result of excision down to the deep fascia and when the blood supply is not too badly impaired. Four full-thickness grafts were used following excision of squamous-cell epithelioma, the result of complicated roentgen dermatitis.

The full-thickness graft, although technically perhaps one of the most difficult to use, makes a pliable and natural looking repair, does not undergo much shrinkage, and can be used for large defects. A full-thickness graft will not take as readily as the pinch or split-skin graft, as our record of failures bears out. Full-thickness grafts should not be used on granulating wounds but are best adapted to defects where excision and immediate grafting are contemplated. The full-thickness graft depends for its nourishment on the tissues with which it has contact, similarly to other skin grafts except those transferred by means of a pedicle. The nutrition of a full-thickness graft is favored by cutting it to the exact size of, or slightly smaller than, the defect that is to be covered and suturing its edges exactly to the edges of the defect, under

slight tension, so that its vascular spaces will be held open and every part of it can be kept closely in contact with the raw surface beneath by a pressure dressing. The binding down of the graft and fixation with a sterile, wet sea sponge for pressure are similar to the care described in relation to a split-skin graft.

Pinch Grafts.—Pinch grafts were used 16 times, on 11 patients. The end results in 4 cases were considered failures (Table VI). These have

TABLE VI

PINCH GRAFTS

CASE	SITUATION OF LESION	RESULT	OTHER PROCEDURES	COMMENT
91	Soles of feet several areas	Success	None	Patient elderly; temporary relief of symptoms but subsequent recurrence
92	Dorsum left hand	Success	None	Graft to thumb 14 yr. following other graft
	Dorsum left thumb	Success	None	
93	Dorsum right ankle	Failure	None	Amputation advised; patient uncooperative
94	Dorsum left foot	Failure	None	Ulcer unhealed after 2 yr.; not excised prior to grafting
95	Left hip	Failure	Biopsy: chronic inflammation with foreign body giant cells	Unhealed more than 1 yr. later, large ulcerated mass; original lesion chondrosarcoma; proved by biopsy
5*	Posterior right thigh	Success	Grafts 4 times previously	Eventually all grafts took
60†	Palm left hand	Success	Pedicle graft previously	
82‡	Left index finger	Success	Amputation left middle finger 15 yr. previously	Sq. cell ep. Grade 3; no recurrence in 4 yr.
84§	Sole right foot	Failure	Full-thickness graft 10 mo. previously	Foot failed to heal due to ulcerating sq. cell ep. Grade 3
85§	Sole right foot	Success	Full-thickness graft previously	
89§	Dorsum left hand	Success	Previous full-thickness graft which failed	Sq. cell ep. Grade 2 dorsum left hand; some stiffness of hands on follow-up
	Right index finger	Success	None	

*This is one of the 32 cases in which excision was performed. Since pinch grafts also were employed, the case appears in this table.

†Since pedicle graft and pinch grafts both were employed in this case, the case is represented both in Table III and in this table.

‡Since amputation and pinch grafts both were employed in this case, the case is represented both in Table IV and in this table.

§Since full-thickness graft and pinch grafts both were employed in this case, the case is represented in Table V and in this table.

many fields of usefulness in the management of complicated roentgen dermatitis. They can be employed following excision and formation of granulation tissue or immediately following excision. Pinch grafts frequently are applied in stages to large defects. Sometimes, by necessity, the grafting is repeated, due to the unusual mortality of these small grafts. It is advisable, when using pinch grafts, to take many small grafts to fill a defect rather than a few large grafts, for the proliferation

around the same amount of skin with small grafts is much greater. Frequently it is advisable to allow granulations to form before applying grafts, especially when the blood supply of the area which requires grafting is of doubtful efficiency. Granulation tissue must be clean, firm, and not exuberant.

It is the custom at the clinic to cover a series of pinch grafts with a sheet of gutta-percha, perforated by cutting off the corners of a many-times-folded sheet. This is held in place by sponges which are moistened with saline solution every three hours for the first three days.

Biopsy Only.—In every case in which excision of tissue is done, with or without grafting or closure of the wound, biopsy really is performed, for all excised tissue is sent to the laboratory for microscopic examination. There were 2 cases of complicated roentgen dermatitis in which biopsy was performed to rule out malignancy. In one of these the patient was a man, 51 years of age, who had received roentgen therapy for an eczematoid lesion of the left leg. This resulted in roentgen dermatitis and was complicated by an injury to the leg which refused to heal. On biopsy the tissue was reported to be benign. In the second case, a man, fifty-six years of age, had received roentgen therapy for eczema of the hands thirty-five years before he came under our care. Roentgen dermatitis of both hands resulted and ulceration had developed. Biopsy disclosed the presence of inflammatory tissue and further surgical treatment was not carried out.

SUMMARY AND CONCLUSION

In a series of 97 cases in which various surgical procedures were used to aid in the cure of roentgen dermatitis, results were generally satisfactory, considering the type of lesion with which we were dealing. Plastic repair in such cases may fail, but, in our experience, ultimate healing usually will take place if thorough excision of the diseased tissue is accomplished.

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AN INVESTIGATION OF TRAUMATIC SHOCK BEARING ON THE TOXEMIA THEORY

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(From the Mayo Foundation)

ATTEMPTS to discover the cause of traumatic shock have been made by many able investigators. As a consequence of their numerous researches, many theories have been proposed to account for the chain of symptoms associated with this condition. The clinical and experimental observations made by Cannon,[4] as a member of the Committee on Shock during the Great War, led him to conclude that the absorption of toxins from injured tissues is the primary cause of traumatic shock. This conclusion was supported by the clinical reports of Quénu and of Delbet and by the experimental findings of Bayliss and of Cornioley and Kotzareff, to mention a few.

The plausibility of this theory and the evidence advanced to support it were sufficient to place the subject of traumatic shock in the category of "settled" questions for nearly a decade. The researches that have been done to test this theory are many. The literature on the subject has been reviewed by Boyers and by Moon; therefore reference will be made to only a few papers which will serve to orient the work that we are presenting.

The toxemia theory was called into question by the extensive series of experiments on traumatic shock reported from 1927 to 1931 by Blalock, who produced shock in dogs after the manner of Cannon and Bayliss. By determining the resulting increase in weight of the traumatized limb by a different method, Blalock concluded that shock produced by such means is the result of local loss of blood and fluids into the traumatized limbs or the adjacent tissues. A few months later, Parsons and Phemister, using the same methods, likewise accounted for traumatic shock on the basis of local loss of fluid. The conclusions of many subsequent investigators, working with similar methods, accorded with those of Blalock and of Parsons and Phemister.

Holt and MacDonald and others have been unable to demonstrate a toxic substance in blood collected from traumatized limbs and injected into another animal. Roome and Wilson expressed, with an hydraulic press, fluid from traumatized and normal limbs of dogs. These fluids

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Received for publication, October 25, 1939.

around the same amount of skin with small grafts is much greater. Frequently it is advisable to allow granulations to form before applying grafts, especially when the blood supply of the area which requires grafting is of doubtful efficiency. Granulation tissue must be clean, firm, and not exuberant.

It is the custom at the clinic to cover a series of pinch grafts with a sheet of gutta-percha, perforated by cutting off the corners of a many-times-folded sheet. This is held in place by sponges which are moistened with saline solution every three hours for the first three days.

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blood volume would not affect the blood volume of the recipient on which the blood from the traumatized limbs was to be tested for toxic substances. Blood could be perfused through the traumatized limbs for several hours, during which time repeated samples could be removed and injected into the recipient. To prevent an increase in blood volume in the recipient quantities of blood equal to those injected could be withdrawn simultaneously from the recipient and, after defibrination, placed in the reservoir of the heart-lung-limb preparation. If toxins were elaborated in the traumatized limbs, blood, repeatedly perfused through them for several hours, might contain a sufficient quantity of toxic substances, if they were present, to cause demonstrable effects on the circulatory system of the recipient.

Dogs were used in all experiments. For the heart-lung-limb preparation the animals weighed about 12 kg. and for the recipients about 8 kg. Pentobarbital sodium (nembutal) was employed as the anesthetic for the heart-lung-limb preparation and the recipients were anesthetized with ether. After the intravenous administration of pentobarbital sodium, 25 mg. per kilogram of body weight, the heart-lung preparation was set up. The blood used in the preparations was obtained from donors and was defibrinated to prevent clotting. Sufficient heparin (Connaught) was added to the apparatus to prevent coagulation of the blood of the heart-lung preparation. The posterior portion of the heart-lung animal was removed anterior to a wire tourniquet placed tightly near the first lumbar vertebra. The aorta and vena cava were cannulated and the aorta was connected with the blood supply from the heart-lung preparation. The sectioned muscles and skin were sutured and a sponge was forced into the spinal foramina to reduce loss of blood from these regions. The hind limbs were then placed in a dry, heated chamber. Blood returning from the vena cava was collected continuously and was either injected into the recipient or returned to the heart-lung-limb reservoir. The time required for the isolation of the hind limbs was about twenty minutes. During that time the limbs were without circulation.

When the circulation of the heart-lung-limb preparation was established, the recipient was prepared. Anesthesia was maintained by autoinhalation of ether. The blood pressure of the recipient taken from the femoral artery was recorded continuously by a mercury manometer and kymograph. Heparin (Connaught) was used as the anticoagulant. Hemoglobin determinations were made on specimens of blood taken from the recipient, using a Cenco-Sheard-Sanford photelometer. The external jugular and femoral veins of the recipient were cannulated for the exchange of blood between it and the heart-lung-limb preparation. The limbs were traumatized mechanically. The exchange of blood was started while this procedure was being carried out or soon after its completion. Blood from the hind limbs was allowed to flow into the external jugular

were injected into other animals. The authors interpreted their results as invalidating the toxemia theory of traumatic shock. Phemister by a viviperfusion technique did not obtain evidence of toxic substances in the dialysate of blood from traumatized limbs.

O'Shaughnessy and Slome reported a series of experiments in which they attempted to discover whether vasodilator substances were present in saline solutions perfused through traumatized limbs. They also performed a number of vividialysis experiments to test for depressor substances in the circulation of dogs following trauma. Their technique allowed dialyzable substances from the blood of one animal to pass through an appropriate membrane to the blood of another without altering the blood volume of either animal. From the results of their experiments they concluded that a depressor substance elaborated at the site of trauma was not responsible for the syndrome of traumatic shock. Fender and Guptill reported the results of cross-circulation experiments. This work was done for the purpose of studying the systemic effects of local damage to tissue on another animal isolated, except through the circulation, from the animal that had received the trauma. They failed to demonstrate the presence of a depressor substance under the conditions of their experiments. They considered their results strong evidence against the theory that a lethal toxin is formed in traumatized tissues. Dragstedt and Mead tested samples of blood and lymph from the damaged tissues on the isolated intestine of the guinea pig and by intravenous injection into etherized, atropinized cats for the detection of histamine or other physiologically active substances. They were unable to demonstrate the presence of a depressor substance.

Cannon[5] emphasized that the toxemia theory of traumatic shock was opposed by negative evidence, and, since positive evidence was lacking, the exclusion of the possibility of traumatic shock resulting from toxemia was unwarranted.

The desirability of positive evidence on the toxemia theory is recognized, but planning experiments that afford a crucial test of the question is another matter. As the problem is examined, the necessity for separating the effects of local loss of fluid, caused by trauma, from the effects of possible toxic substances is at once apparent. If such a separation could be attained, it would be a step forward. Thereafter other features of the problem could be dealt with as they arose. The present report comprises our plan of attack and the results of our efforts to solve this problem.

METHODS

To meet the requirements demanded of the proposed experiments, it was necessary to use heart-lung-hind limbs preparations. These preparations will be referred to hereafter as the heart-lung-limb. The limbs could be traumatized as desired and the consequent loss of circulating

TABLE I

DATA ON EXPERIMENTS

EXPERIMENT NO.; DOG WEIGHT, KG.	TYPE OF EXPERIMENT	TIME HEART-LUNG-LIMB PREPARATION FUNCTIONED	PERIOD OF TRANSFUSION OF RECIPIENT	NUMBER OF EXCHANGES OF 100 C.C. OF BLOOD	PERIOD OF TRAUMA	CONTROL MEAN ARTERIAL BLOOD PRESSURE OF RECIPIENT, MM. HG	BLOOD PRESSURE AT LAST EXCHANGE OF BLOOD, MM. HG	LENGTH OF TIME RECIPIENT LIVED AFTER EXPERIMENT, HOURS
								Lived
1 8.5	Autotransfusion, control		3 hr.	21	0	100	104	18
2 9.6	H-L-L,* control	5 hr. 25 min.	4 hr. 25 min.	19	0	125	130	8
3 6.2	H-L-L, control	6 hr.	3 hr. 25 min.	17	0	90	70	15
4 8.3	H-L-L, trauma to limbs	5 hr.	3 hr. 20 min.	21	10 min. later—90 min. 15 min.	114	104	8 (?)
5 8.0	H-L-L, trauma to limbs	4 hr. 25 min.	2 hr. 45 min.	23	45 min.	150-130	60 Fell as low as 40	0
6 7.8	H-L-L, trauma to limbs	4 hr. 45 min.	3 hr. 12 min.	21	35 min.	150	60	0
7 9.0	H-L-L, trauma to limbs	3 hr. 35 min.†	2 hr. 20 min.	10	40 min.	120	50	

H-L-L, heart-lung-limb.

†Perfusion of the limbs was continued for 30 minutes with a Dale-Schuster pump after the heart-lung preparation failed.

of the recipient by gravity. An exchange of 100 c.c. of blood was made at seven- to fifteen-minute intervals. Simultaneously 100 c.c. of blood was withdrawn from the femoral vein of the recipient. After being defibrinated the blood was added to the reservoir of the heart-lung-limb preparation. This exchange of blood continued throughout each experiment. Control experiments were done in the same way except that the limbs were not traumatized. In one experiment the limbs were traumatized for two short periods. The limbs of the preparation were weighed immediately after removal and at the end of the experiment.

RESULTS

The essential data on all experiments are given in Table I. Six experiments were done in the manner just described. An additional experiment was carried out early for the purpose of determining the effect on the blood pressure of repeatedly withdrawing, defibrinating, and reinjecting a dog's own blood. This experiment, which will be briefly described, served as a control on the controls, as it were.

All procedures were carried out as already described for the recipient in the other experiments. Under ether anesthesia a continuous record of the blood pressure was made from the femoral artery. The external jugular and femoral veins were cannulated for the exchange of blood. Enough blood was taken from a donor to furnish 100 c.c. of defibrinated blood for the first transfusion. While the recipient was being given this blood, an equal quantity was withdrawn from the femoral vein. The blood removed was defibrinated and returned to the circulation of the same dog. This was repeated at approximately ten-minute intervals for about three hours. During this time twenty-one such exchanges were made. That the dog was not seriously affected by the experiment was clearly indicated by the fact that the initial blood pressure of 100 mm. of mercury was maintained throughout the experiment and that the animal completely recovered (Table I, Experiment 1).

In the two control experiments in which the hind limbs of the preparation were not traumatized, the blood pressure of the first recipient was 125, that of the other 90. At the end of the first experiment, which lasted four hours and twenty-five minutes, and at the end of the second experiment, which ran for three hours and twenty-five minutes, the blood pressures were respectively 130 and 70. The hemoglobin values were practically unchanged in both cases. There was an increase in the weight of the perfused hind limbs amounting to about 7 per cent. Both recipients died, the one used in the first instance after eighteen hours, and the one used in the second after about eight hours. The cause of death was undetermined (Table I, Experiments 2 and 3).

It was established by the experiments just described that the blood pressure and hemoglobin concentration of the recipients were not seriously affected during the period of observation as a result of transfusions of blood from nontraumatized hind limbs. Therefore, in the remainder

The next experiment was similar in most respects to the one just described. The limbs were traumatized for thirty-five minutes, after which exchanges of blood were begun. As a result of ten exchanges which required seventy-six minutes, the blood pressure decreased to 70. From this point there was a gradual rise in blood pressure for a time, but, as the exchanges were continued, a decline began which ended in the death of the recipient three hours and twelve minutes after the first exchange of blood from the traumatized limbs.

In the final experiment in this series the limbs were traumatized for forty minutes and the procedure followed differed from that already described in one particular that may be of significance. After a control exchange of blood, which did not affect the blood pressure, two exchanges of blood were made while the limbs were being traumatized. Before another exchange was begun, the blood pressure had decreased from 120 to 50. During the succeeding seven exchanges, the blood pressure declined further and the death of the recipient occurred three hours and five minutes after the first exchange of blood from the injured limbs (Fig. 1). When the blood pressure had reached a low level, the administration of ether was repeatedly stopped, in one instance for twenty-five minutes, but the blood pressure was unaffected. The heart-lung preparation failed after the seventh exchange of blood, but perfusion of the limbs was continued with a Dale-Schuster pump. The increase in the concentration of hemoglobin of the recipient was about 8 per cent in the last two experiments. The weight of the traumatized limbs was nearly doubled in all of the experiments.

At the end of each experiment the muscles of the perfused limbs were stimulated with an induced current. There was a vigorous response in every instance, which demonstrated the excellent physiologic condition of the muscles of the limbs (Table I).

COMMENT

Moon has summarized the evidence against the toxemia theory of traumatic shock and has concluded that the methods used, the results obtained, and the interpretation of the data do not justify the exclusion of the toxemia theory of shock from further consideration.

The difficulty of distinguishing between local loss of fluid and the effect of possible toxic substances was circumvented in our experiments by complete isolation of the traumatized limbs from the test animal or recipient. The possibility of a toxic substance being liberated in amounts insufficient to produce an effect on a single injection was met by repeated injections of blood from the injured limbs. The contention that massive injections of blood or fluid might conceivably mask the presence of toxins by increasing the blood volume of the recipient sufficiently to offset the depressor effect of such toxins as might be present was met by removing from the recipient a volume of blood equal to that injected.

of the experiments the hind limbs of the heart-lung-limb preparation were traumatized to determine the effect on recipients of blood from such limbs.

In the experiment to be considered now, the perfused hind limbs were traumatized for ten minutes at the beginning of the experiment and ninety minutes later they were again injured for a period of fifteen minutes. The blood pressure of the recipient was 114 at the beginning and 104 at the end of the experiment. In all, twenty-one exchanges of blood were made in three hours and twenty minutes. The injured limbs had increased in weight from 4.75 to 9.5 pounds. The concentration of hemoglobin was increased about 8 per cent. The recipient died fifteen hours after this phase of the experiment was finished (Table I, Experiment 4).

If the traumatized tissues had liberated a toxic substance in the experiment just described, the quantity was insufficient to affect the blood pressure of the recipient more than was done in one of the control experiments. It appeared that the injury to the limbs should be prolonged and given in one period at the start of the experiment. This was done in the three experiments now to be described.

In the first experiment of this series two control exchanges of blood were made before the perfused limbs were injured; the blood pressure remained near the control value of 150 to 130. The first exchange of blood following injury to the limbs for forty-five minutes reduced the blood pressure to 104 but it gradually recovered before the next exchange ten minutes later. The blood pressure declined but gradually rose to near its previous level after each successive exchange until the fifth. Thereafter it continued slowly to decline. When the fourteenth exchange of blood from the injured limbs was finished, the blood pressure had decreased to 50. The administration of the anesthetic was discontinued at this time, which was two hours and thirty-one minutes after the first exchange of blood from the traumatized limbs. Administration of ether was not resumed for two hours and fourteen minutes. Three more exchanges of blood caused an additional decline of blood pressure of 10. Subsequently the blood pressure slowly increased to 60, where it remained after the final exchange of blood. Failure of the heart-lung preparation prevented carrying this phase of the experiment further.

As already shown, the blood pressure continued to decline for some time after ether anesthesia was discontinued. After forty-four minutes without ether the blood pressure began to rise slowly. Two hours and twenty-five minutes after the last exchange of blood or at the time of the final observation at 9:15 P.M., the blood pressure had risen to 90.

During the period that ether was withheld, the recipient did not move spontaneously or respond to any of the usual stimuli. When ether anesthesia was resumed, the blood pressure continued to rise.

The animal died before morning. It could not have lived more than eleven hours. On the basis of post-mortem evidence, it was thought that death probably occurred about eight hours after the last observation.

The next experiment was similar in most respects to the one just described. The limbs were traumatized for thirty-five minutes, after which exchanges of blood were begun. As a result of ten exchanges which required seventy-six minutes, the blood pressure decreased to 70. From this point there was a gradual rise in blood pressure for a time, but, as the exchanges were continued, a decline began which ended in the death of the recipient three hours and twelve minutes after the first exchange of blood from the traumatized limbs.

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That this treatment alone using the dog's own blood did not have serious consequences was shown by the first experiment described.

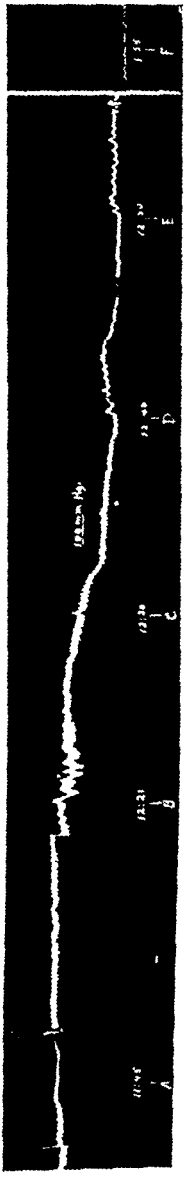


Fig. 1.—Arterial blood pressure of dog that received blood from hind limbs before and after trauma. At *A* 100 c.c. of blood from recipient was exchanged with blood from hind limbs before trauma. At *B* 100 c.c. of blood from recipient was exchanged with blood from limbs after trauma. At *C*, *D*, *E*, and *F* similar exchanges were made. At *E* administration of ether was stopped for six minutes. Exchanges, not indicated on the tracings, were carried out at 1:07, 2:20, 2:30 and 2:40. The recipient died at 3:25. At 11:10 the hemoglobin of recipient was 16.2 Gm.; just before death it was 17.7 Gm.

The fact that the recipients in the control experiments died several hours after the completion of the experiments cannot be ignored. We recognize the value of a thorough investigation of the ultimate cause of these deaths not only because of its bearing on the present discussion, but also because of its possible importance in connection with the sub-

ject of perfused organs generally. The importance of the fact that the recipients in the control experiments did not show severe reactions during the period of observation should be stressed, however, since the recipients of the blood from the severely traumatized limbs were decidedly affected within forty minutes after the first exchange of blood. We can state without hesitation that the anesthetic was not responsible for this result. Ether was used for the reason that it could be readily controlled or withheld as occasion demanded. That the low blood pressure seen early in certain of the experiments was not owing to the anesthetic was proved by the fact that a change in the animal's condition was not seen when the anesthetic was withdrawn for as long as one hour.

By the process of elimination there seems no other alternative but to acknowledge that severe trauma to the perfused hind limbs was productive of results significantly different from those of the control experiments. Whether some factor not recognized by us in our experiments was responsible for the rapid death of the recipients of blood from severely traumatized limbs or whether toxic substances arising from the injured tissues were responsible must be decided by further research. The most that can be said at present is that our results furnish suggestive evidence for the toxemia theory of traumatic shock.

SUMMARY AND CONCLUSIONS

By means of heart-lung preparations, the hind limbs of dogs have been perfused and the effect, on recipients, of blood from perfused unaffected and traumatized limbs has been observed. While 100 c.c. of blood from the perfused limbs was being given to the recipient, an equal quantity was withdrawn, defibrinated, and added to the blood reservoir of the heart-lung-limb preparation. As many as twenty-three exchanges of blood were made during the course of the experiments which ran from two hours and twenty minutes to four hours and twenty-five minutes.

Blood from unaffected limbs or from limbs traumatized for short periods did not produce shock in the recipients as determined by blood pressure and the concentration of hemoglobin during the period of observation. However, death occurred in one experiment eight hours and in another eighteen hours after the experiments were completed. Blood from limbs traumatized for thirty-five to forty minutes caused a significant decrease in blood pressure within forty minutes after the first exchange of blood and death a few hours thereafter. Repeated removal, defibrination, and reinjection of a dog's own blood was without effect on the blood pressure and the animal so treated fully recovered.

The bearing of anesthesia and certain other factors on the results has been discussed.

It is concluded that the results of the experiments described in this report furnish suggestive, but not conclusive, evidence for the toxemia theory of shock.

That this treatment alone using the dog's own blood did not have serious consequences was shown by the first experiment described.

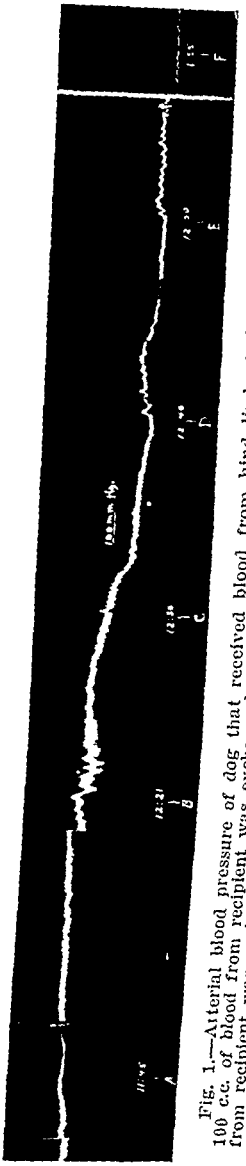


Fig. 1.—Arterial blood pressure of dog that received blood from hind limbs before and after trauma. At *A* 100 c.c. of blood from recipient was exchanged with blood from hind limbs before trauma. At *B* 100 c.c. of blood made. At *B* administration of ether was stopped for six minutes. At *C*, *D*, *E*, and *F* similar exchanges were carried out at 1:07, 2:20, 2:30 and 2:40. Exchanges, not indicated on the tracings, were 16.2 Gm.; just before death it was 17.7 Gm. The recipient died at 3:25. At 11:10 the hemoglobin of recipient was

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REPORT OF FIFTY-NINE CONSECUTIVE CASES OF UNUNITED FRACTURE OF THE NECK OF THE FEMUR

PAUL B. MAGNUSON, M.D., CHICAGO, ILL.

THIS report is based on the operative treatment of 59 cases of ununited fracture of the neck of the femur; 41 have been done according to my modification of the Brackett operation; the remaining 18 cases have been divided as follows: 7, Whitman operation; 5, high intratrochanteric osteotomy; 2, Colonna operation; and 4, miscellaneous. By miscellaneous is meant that the operation could not be classified as any one of the preceding, and was devised to suit the needs of the particular case.

The ages of the patients varied from 34 to 84 years, with an average age of 57. The weight varied from 240 to 115 pounds, with an average weight of 159. Females predominated in a ratio of 3:1. The average shortening before operation was 1.5 inches; after operation, ¾ inch. The average period of time between injury and operation was 18.5 months, the longest interval being 84 months and the shortest 3 months.

This report covers a period from 1925 to 1937, inclusive. We have been able to follow all these cases with one exception and have been able to examine most of them for a number of years following operation. Some of the older cases have been followed by letter during recent years. The results are based on the patient's estimate as judged by letter or statement, plus observation by examination.

In selecting any operation, the surgical risk involved for the case in hand is one of the most important considerations. The operation has not proved to be shocking. High blood pressure was not considered a contraindication. Obesity complicated the mechanical difficulties, but it is not in itself a contraindication. Avertin with nitrous oxide has been the anesthetic of choice and was used in all these cases. There have been 2 deaths in the entire series, including all types of operation, a mortality of less than 4 per cent. The operating time varied from 45 minutes to 1 hour and 10 minutes.

The basic principles to be fulfilled in this procedure are to re-establish normal weight-bearing between the shaft of the femur and the acetabulum (Fig. 4). Whether the head should be interposed in one way or another depends largely on its condition at the time of operation. There has been a good deal of discussion about the viable head. It is my opinion, after having followed some of these cases for fourteen years, that in many cases it is impossible from the x-ray evidence alone to determine whether or not the head is viable. The type of operation is not decided upon until the fracture is exposed and the head, the

Received for publication, October 6, 1939.

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The question has been asked what type of case is best suited for the modified Brackett operation. As mentioned before, we have made no choice so far as type of physique is concerned. We believed that all the patients upon whom we operated had no serious disease and had a number of years of useful life ahead of them if they could walk. We did not consider age; two were more than 80 years of age. Both these patients are living at this time, one being now over 90 years of age. One, a man, weighed 130 pounds and the other, a woman, weighed 175 pounds.

The decision for the type of operation is never made definitely until the joint is exposed. No consideration has been given to the portion of the neck remaining. In all cases the neck was completely absorbed so far as the x-ray showed, but in some there was considerably more bone than was apparent in the x-ray.

The technique employed is an anterior approach along the lateral border of the sartorius muscle, extending backward somewhat along the outer edge of the ilium. The attachment of the rectus femoris is exposed and cut transversely or obliquely through its tendinous origin. The muscle is turned down and covered with a warm moist laparotomy pad. The capsule is exposed; the plexus of veins which lies immediately anterior is clamped and ligated; and the anterior capsule is cut parallel to its fibers which, because of the displacement of the shaft, will be found to run transversely instead of obliquely. The capsule is then cut away from the acetabulum and removed as completely as possible down to its attachment on the shaft. The heavy fibrous tissue which lies between the head and the shaft is completely removed. Any adhesions and all fibrous tissue around the head or extending between the head and the edge of the acetabulum are completely removed. Again mentioning this may seem superfluous, but it is an extremely important factor in the success of the operation. A sharp chisel is used to remove the fibrous tissue from the fractured surface. Observation is made as to whether there is any bleeding from the head, the density and consistency of the bone, and the size of the remaining portion of the head. When the fibrous tissue is completely removed from the space between the shaft and the head in this dissection, a Murphy skid is used to pry the shaft outward and hold it away from the acetabulum, completely exposing the fractured surface of the head.

When the head is free and the shaft pulled away so that there is good apposition, the head is rotated in all directions and the cartilage of the acetabulum and head is examined to note any serious erosion of cartilage, the color and thickness of the cartilage, and whether there are any adhesions between the cartilaginous surfaces. If the ligamentum teres has not been torn, the head cannot be rotated more than 50 per cent. I have replaced the head on the end of the shaft, even when the ligamentum teres was torn, and seen it function in one case over

remainder of the neck, and the upper end of the femur are inspected. In many cases where the x-ray shows necrotic areas and one would suspect that the head was at least partly necrotic in the sense of lacking circulation, it has been found that, if put to work, the head will bear weight and function normally. Even after a period of nine years of such apparently normal function, the x-ray has shown the same necrotic areas. We, therefore, judge whether the head shall be removed or shall be put to work, at the operating table, without any definitely preconceived idea of what operation will be done.

If the head is firm and can be freely moved in the acetabulum after the fibrous tissue is thoroughly dissected away from the fractured surface and the rim of the acetabulum, or if there is any bleeding from the fractured surface of the head after the fibrous tissue is thoroughly removed, the head is fitted over the end of the shaft of the femur in the way described previously.[1] I believe that, if the head is brought into wide contact with the upper end of a well-nourished shaft and held firmly between that shaft and the acetabulum, the circulation is restored sufficiently to allow the head to function. The cartilage of the head and the cartilage lining the acetabulum must also be free from adhesions, and, although there are many times areas of erosion in this cartilage, the head will bear weight painlessly and remain freely movable. The cartilage should be examined as carefully as possible by rotating the head, but not completely displacing it. There must be sufficient capacity in the remaining head to allow excavation of proper size and shape to receive the upper end of the shaft. The fibrous tissue which frequently completely binds the head to the acetabulum must be removed to allow the remaining head absolutely free motion. If this is not done, the shaft will pry out of its new position. To assure success, it must be possible to place the head in a valgus or adducted position in direct weight-bearing line with the shaft, and it must maintain that position when the thigh is in not more than 15 degrees of abduction. If the upper end of the shaft actually slips out of the head when the leg is brought parallel to the long axis of the body, it is possible that there is a lever action between the shaft and the hypertrophied and scarred transverse acetabular ligament. It should be possible to place the head in marked valgus position without unduly stretching the ligamentum teres.

If these conditions can be met, the modified Brackett operation results in more painless, movable, weight-bearing hips than any other reported here, excepting the high oblique intratrochanteric osteotomy. This is done on cases that have good apposition, with the idea only of restoring the weight-bearing line between the shaft and the head, assuming that there is very heavy fibrous or partial bony union. In selected cases this procedure gives most satisfactory results.

a way that it will sever the posterior lip of the greater trochanter which lies a considerable distance back of the neck at its base. The trochanter is removed by driving the chisel downward, backward, and outward. The chisel must be placed in such a way that it will remove not only the top of the trochanter lying above the base of the neck, but also the reflecting posterior lip far enough down to prevent interference with bringing the shaft up into the head. If this lip is not removed, it strikes the posterior rim of the acetabulum and interferes with fitting of the shaft into the head, and in abduction will pry the shaft out of the head.

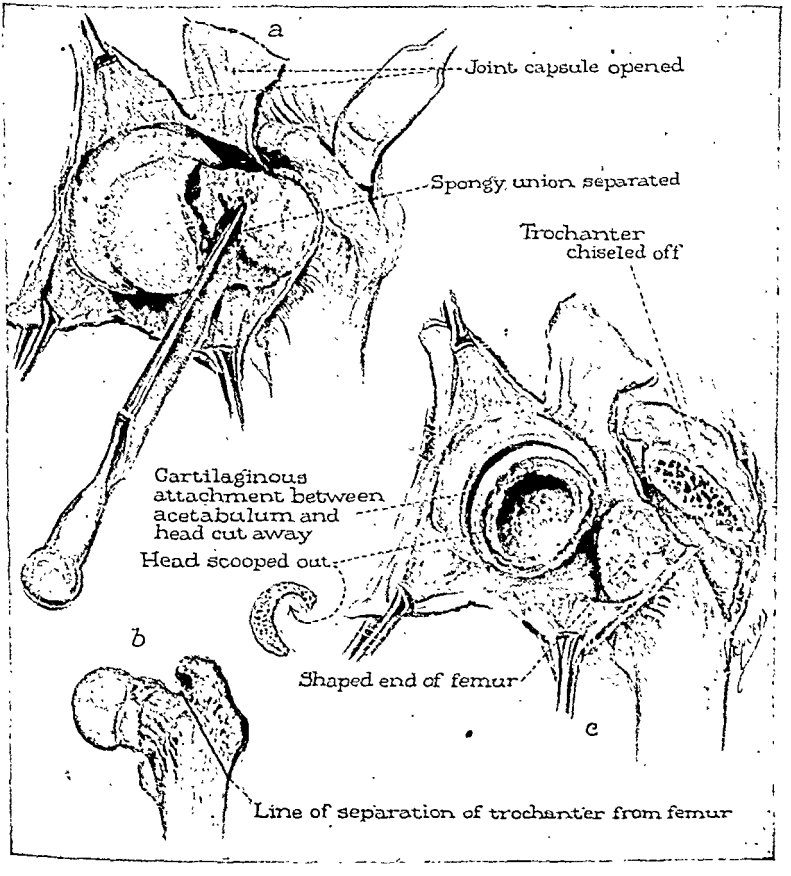


Fig. 2.—Second stage of reconstruction of hip. *a*, Large mass of fibrous tissue between head and trochanter removed; *b*, line of incision for removal of trochanter; *c*, hollowed-out head and rounded end of shaft, the curves of which correspond. (From Magnuson: *Fractures*, J. B. Lippincott Co.)

The end of the shaft is then freed from all attachments of muscle and fibrous tissue for a distance of 1.5 to 2 inches, and shaped somewhat in the form of a parabola, not a hemisphere. The head is then excavated with a motor-driven burr, an enlargement of a round dental burr. The apex of the parabola is directed toward the junction of the

a period of seven years without any further necrosis. If the ligamentum teres is intact, it should be noted whether the head can be rotated in a valgus position without putting undue tension on this ligament.

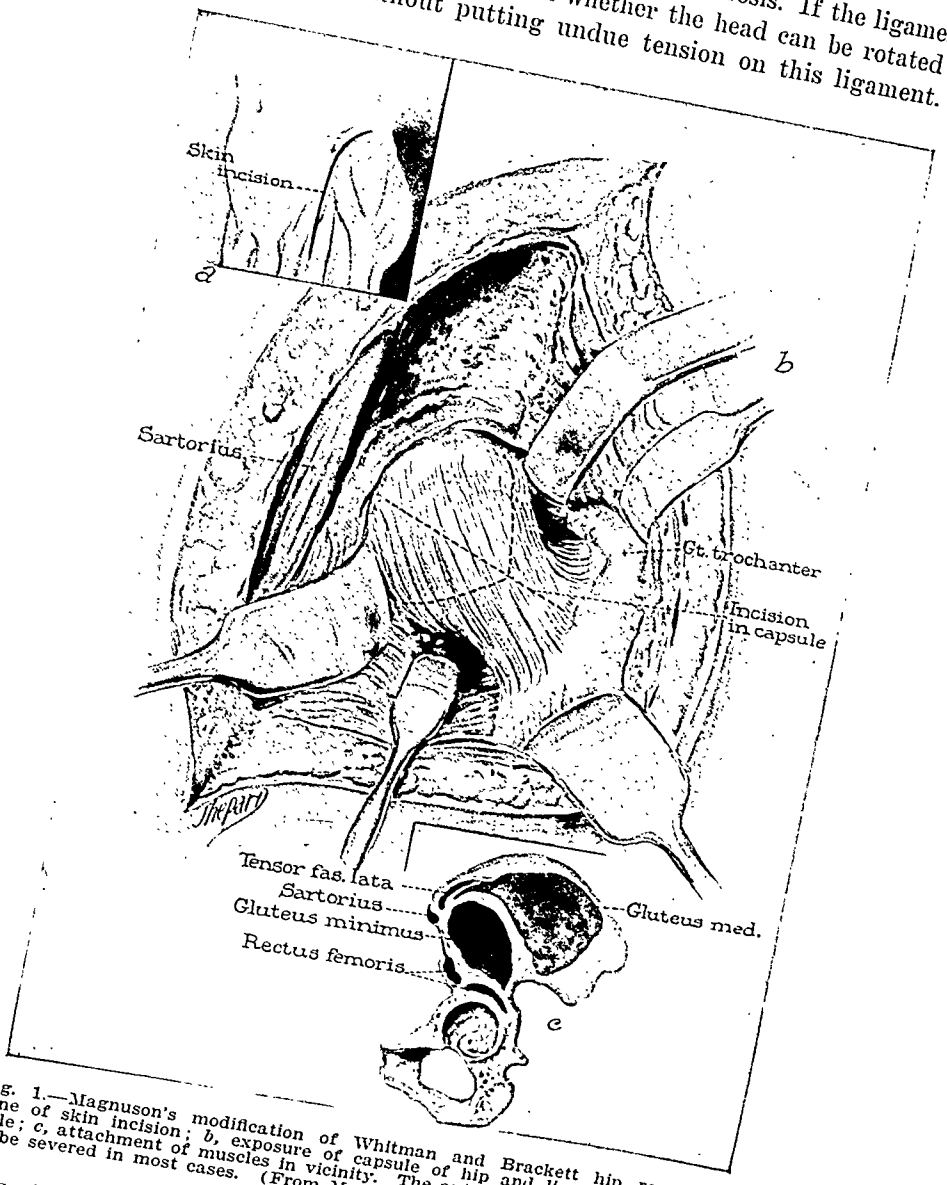


Fig. 1.—Magnuson's modification of Whitman and Brackett hip reconstruction. *a*, Line of skin incision; *b*, exposure of capsule of hip and lines of incision in the capsule; *c*, attachment of muscles in vicinity. The anterior rectus femoris attachment must be severed in most cases. (From Magnuson: *Fractures*, J. B. Lippincott Co.)

It is at this point that the decision is made as to whether or not the modified Brackett type of operation is indicated. If so, the upper end of the shaft is brought forward into the wound and internally rotated. The greater trochanter is removed by a broad chisel, preferably slightly curved. The posterior edge of the chisel is placed in such

it freely in all its motions, then adduct to 15 degrees and abduct to 45 degrees. If the shaft has a tendency to pry out of the head when the leg is brought parallel to the long axis of the body, it is probable that it does not fit deeply enough into the head; or that the cavity in the head is not properly shaped to retain it firmly; or that the transverse ligament of the acetabulum is acting as a fulcrum; or the ligamentum teres limits the head in valgus position. If the transverse ligament is at fault, it must be cut so the shaft may be moved medially.

After the shaft has been well fitted into the head and has been tested to see that the head follows all motions of the shaft freely, the leg is brought into 30 degrees of abduction. A two-prong sharp hook retractor is caught over the tip of the trochanter and it is dragged downward and outward as far as possible. A piece of malleable iron wire or heavy braided silk is passed through the muscle attachment at the tip of the trochanter, and through a hole drilled in the cortical bone of the shaft in the lower angle of the incision. The trochanter is then held firmly in a position which displaces it downward and outward. One loop of strong material is sufficient. The tendon of the rectus femoris is sutured and the wound closed. The capsule has been cut away; therefore, there is nothing overlying the fracture except the rectus femoris. Heavy compression dressings are applied with a spica muslin bandage.

Postoperative fixation is by Adams' abduction plaster boots, each leg being abducted about 30 degrees. These boots are bivalved, and motion is started in the well leg in three or four days. Flexion of the knee and ankle, and active resistance muscle exercises are given daily. The patient is allowed to sit up in bed and is turned prone for one hour twice each day. Motion in the operated leg is started within a week, and, the cast being bivalved horizontally, the knee and ankle are given active exercise. The hip is flexed, but is never brought into more than 20 degrees of adduction and out as far as 45 degrees of abduction. When the patient is turned, after the first two weeks, a pillow is placed under the knee of the injured leg in order to retain full extension of the hip.

Weight-bearing is permitted in eight weeks. There is no protection in the way of a splint. The patient is usually started walking supported by two individuals in whom he has confidence. This is important. The surgeon and his first assistant can accomplish much more in the first two weeks than can be gained by the use of crutches in a number of weeks. The patient is urged to put full weight on the hip. There may be some tenderness, but it seems to be largely in the muscles and not in the joint. If the head remains firmly on top of the shaft, with direct weight-bearing between the head and the shaft and acetabulum, no pain occurs in the joint, and the shaft is constantly forced into the head.

upper and middle thirds of the arc of the head, which has been shaped to correspond with the upper end of the shaft. This must be in full view in the operative field. When the cavity has been prepared to correspond to the upper end of the shaft, the small end of a Murphy skid is placed within the cavity; the leg is brought into abduction and the shaft pried into the head. It will sometimes be found that the cavity is not large enough, and several fittings may be necessary. The test we use is to rotate the shaft and see if the head follows

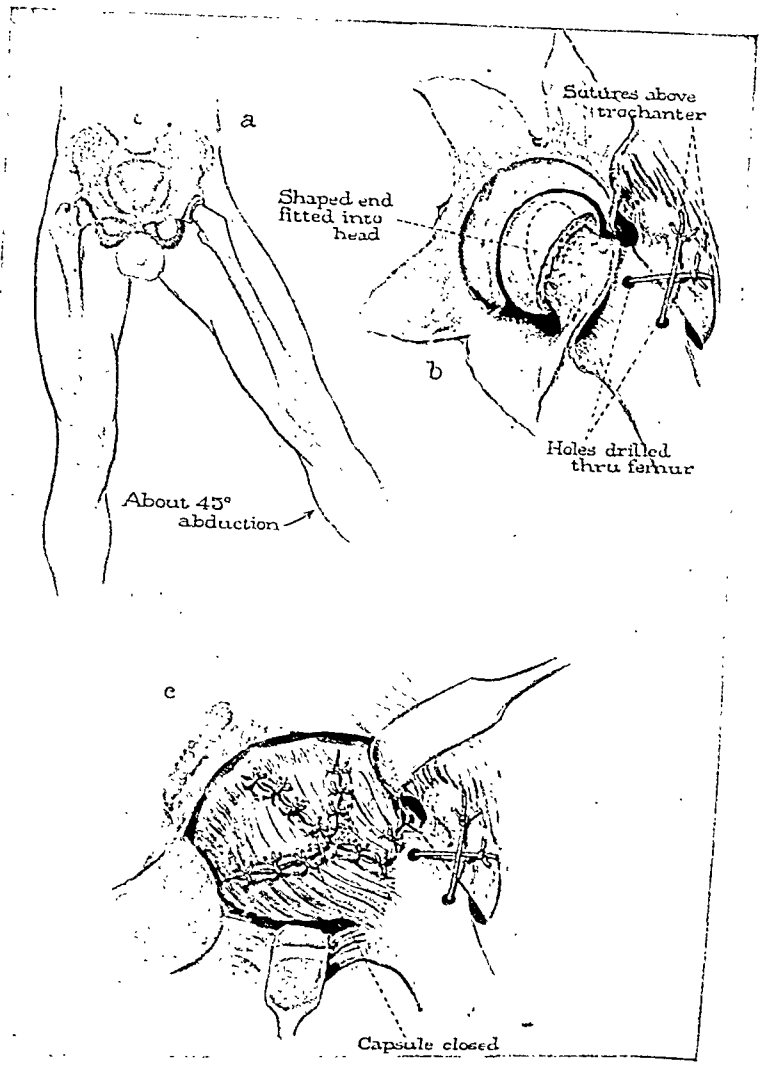


Fig. 3.—Third stage of operation. Rounded end of shaft fitted into hollowed-out head; trochanter replaced downward and outward from its original location. *a*, Position of shaft in head at completion of operation; *b*, head hollowed out in the form of a parabola, with the end of shaft fitted into it and the trochanter attached to the upper end of the femur below and lateral to its former position; *c*, closure of capsule. (From Magnuson: *Fractures*, J. B. Lippincott Co.)

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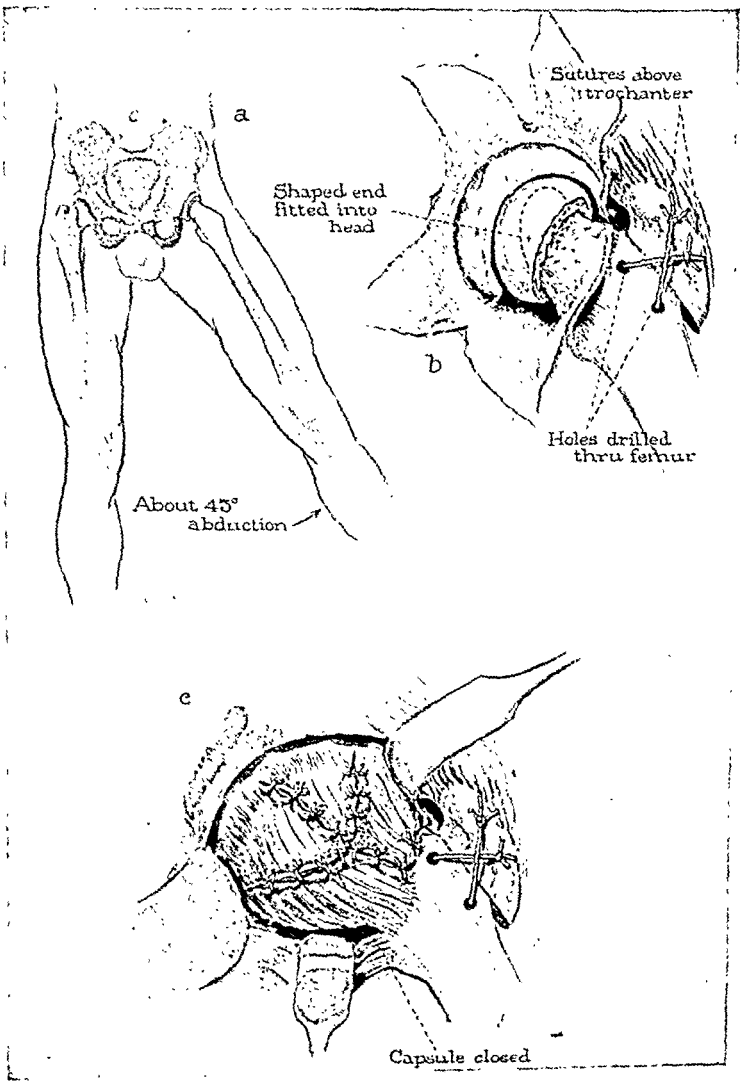


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The only specimen which we have been able to obtain was one in which there was microscopic evidence of bony union. The fracture occurred eighteen months prior to the operation and the specimen was obtained at autopsy three months after the operation.

Of the 41 cases reported, 28 were good, painless functioning hips and bore weight painlessly, allowing the patient to resume his former occupation. The question has been asked whether the patient could dress the foot on the injured side. Whether all could do so we cannot say. The records were not made with this in view. The patients have not complained of this, and all have been able to sit comfortably in a chair and bend the knee to a right angle or better.

In the remainder of the cases there have been two deaths. In six the results were poor, the shaft having slipped out of the head with lack of weight-bearing stability. In one of these a Whitman operation has been done and in another a high osteotomy, within the last two years. Both of them are now bearing weight with comfort. One head collapsed and gradually disintegrated except for the weight-bearing fragment, but the function remained good. One case is questionable. The patient felt that the hip was much improved. She was walking with a cane, but I could not determine that there was good weight-bearing, and in our opinion the lesser trochanter was bearing against the lower edge of the head which had rotated into a valgus position. From one patient we have been able to get no report.

In no case has flattening of the head been seen such as is found following dislocation of the hip.

Mention must be made of the distorted appearance of the hip seen occasionally following operation. It seems almost impossible to reproduce in the x-ray what is seen at the operating table. The cases which give an impression of great security and good alignment at the operating table show the shadow of bone apparently in a position which could not bear weight, yet the case progresses to a satisfactory result.

This operation has also been used in subcapital fracture of the neck of the femur in six cases and in these fresh fractures it has resulted in complete restitution to normal. In ununited fractures, however, because of the absorption of bone of the neck of the femur, the formation of large amounts of fibrous tissue within the capsule, the hardening of the capsule, and the weakness of the muscles from long disuse, this cannot be achieved. There must be some shortening because of the absorption of the neck, and this in itself interferes with the normal range of motion in the hip. The amount of dissection necessary at the time of operation is so extensive that there is probably considerable scar tissue around the hip joint. Many months are required for the reestablishment of control of the hip joint by the muscles which are responsible for its motion.

Eight weeks is adequate time for the trochanter to unite. We have never seen a case in which the trochanter has failed to unite. It seems that the time of the surgeon and his first assistant is well spent in the first few days of walking, in the establishment of confidence in the mind of the patient that the hip is solid and weight can be borne without fear. Some younger patients have used crutches only for two weeks, and then resorted to canes. As soon as the muscles are able to support weight, if the head is in the position it should be, there is no feeling of weakness, because there is firm support between the shaft and the head of the acetabulum.

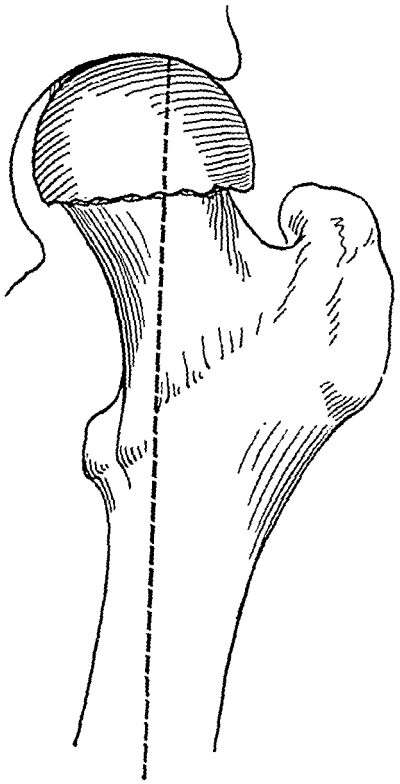


Fig. 4.—Firm impaction in valgus position is the ideal way in which the head should be interposed between the shaft and the acetabulum.

The percentage of bony unions is undeterminable. In cases which have been walking for eight or ten years after this operation, the return to continuous bony structure is so gradual that we have not been able to determine when it occurs. We believe that there is probably not bony union at the time weight-bearing is allowed, but, judging from experience, if the head is free in the acetabulum and the weight is transmitted in direct line with the head held firmly between the shaft and the acetabulum, even in a dead head creeping substitution will take place.

AN ANATOMIC AND ROENTGENOLOGIC STUDY OF THE WRIST JOINT

Observations on a Case of Recurrent Radiocarpal Dislocation Complicating Madelung's Deformity and Its Surgical Correction

Thomas Horwitz, M.D., Philadelphia, Pa.

THE MOVEMENTS of the wrist joint are shared by several articulations: the radiomeniscocarpal, intercarpal, and carpometacarpal joints. The radius and articular disk form a transversely elliptical, concave surface (the glenoid), and the navicular, lunate, and triangular carpal bones form a smooth convex surface (the condyle). The intercarpal joints include the arthrodial joints between the carpal bones in the proximal and distal rows and the S-shaped articulation (mediocarpal) between the two carpal rows (Fig. 1). Since the wrist lacks only marked rotation on a vertical axis (it possesses this motion to a limited extent), it has most of the movements of an enarthrodal joint, without the structural weakness peculiar to such joints. Pronation and supination in the forearm supplement the circumduction possible in the wrist joint complex, duplicating all the movements possible in a ball-and-socket joint.

LIGAMENTS OF THE WRIST JOINT

The *anterior radiocarpal ligament* runs obliquely from the radial styloid process and articular margin downward and ulnarward to attach to the navicular, lunate, and triangular bones of the proximal carpal row and to the capitate bone (os magnum) in the distal row. The *anterior ulnarcarpal ligament* runs obliquely downward and radialward, crossing behind the radiocarpal ligament, from the ulna to the capitate. The *posterior radiocarpal ligament* passes downward and ulnarward from the articular margin of the radius to the lunate and capitate. The *internal lateral (ulnar collateral) ligament* descends from the ulnar styloid process and divides, the anterior fasciculus going to the pisiform bone, the posterior to the triangular bone. The *external lateral (radial collateral) ligament* passes from the radial styloid process to the anteroexternal surface of the navicular bone. The carpal bones are held together by short volar, dorsal, and interosseous ligaments (Figs. 1 and 3).

The anterior ligament is strong and thick; the posterior ligament is comparatively thin. The latter, however, is strongly reinforced by the fibrous sheaths of the extensor tendons with which it is intimately

Received for publication, November 10, 1939.

Nevertheless, when the shaft of the femur bears weight in direct line with the head and into the acetabulum, a comfortable, weight-bearing hip with a movable head can be obtained. The patient can be restored to useful activity and be comfortable for the remainder of life so far as the hip is concerned, in spite of the fact that extremes of motion may never be established. Restitution to complete normal, however, in my opinion is not to be expected in any reconstruction operation for long-existent ununited fractures of the neck of the femur.

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2. The integrity of the distal end of the ulna and the prevention of its displacement depend, in the order of their importance, upon (a) the extensor carpi ulnaris tendon and its sheath (Fig. 2 *a*), (b) the triangular fibrocartilage, and (c) the anterior and posterior distal radioulnar ligaments.

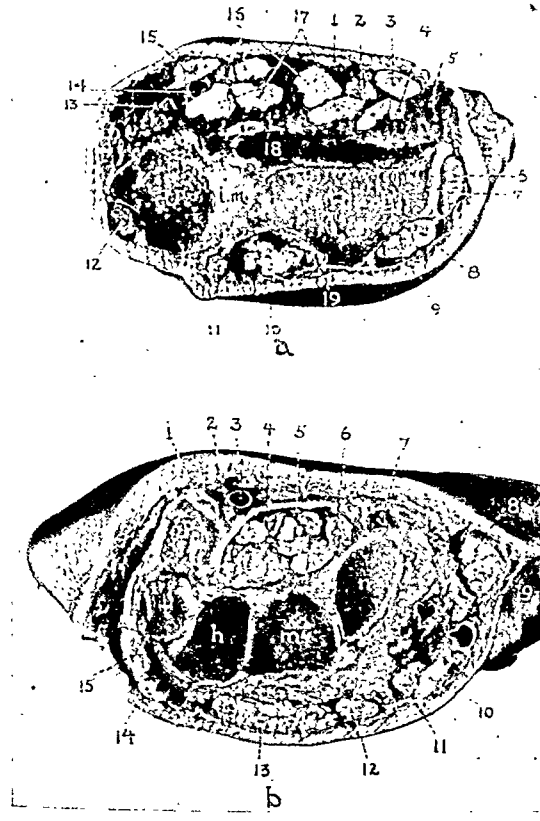


Fig. 2.—*a*, Cross section of the right forearm 1.25 cm. proximal to the dorsal margin of the radiocarpal joint: *R*, radius; *U*, ulna; *i.m.*, interosseous membrane; *1*, palmaris longus tendon; *2*, median nerve; *3*, flexor carpi radialis tendon; *4*, flexor pollicis longus tendon; *5*, radial artery; *6*, abductor pollicis longus tendon; *7*, extensor pollicis brevis tendon; *8*, extensor carpi radialis longus tendon; *9*, extensor carpi radialis brevis tendon; *10*, extensor digitorum communis and extensor indicis tendons; *11*, extensor digiti quinti tendon; *12*, extensor carpi ulnaris tendon; *13*, ulnar nerve; *14*, ulnar artery; *15*, flexor carpi ulnaris tendon; *16*, flexor digitorum sublimis tendons; *17*, flexor digitorum profundus tendons; *18*, pronator quadratus; *19*, extensor longus pollicis tendon. *b*, Cross section of right wrist 2 cm. distal to the dorsal margin of the radiocarpal joint: *p*, pisiform; *t*, triangular; *h*, hamate; *m*, os magnum (capitate); *n*, navicular; *1*, flexor carpi ulnaris tendon; *2*, ulnar nerve; *3*, ulnar artery; *4*, flexor digitorum sublimis and profundus tendons; *5*, palmar fascia; *6*, flexor pollicis longus tendon; *7*, flexor carpi radialis tendon; *8*, abductor pollicis longus tendon; *9*, extensor pollicis brevis tendon; *10*, extensor pollicis longus tendon; *11*, extensor carpi radialis longus tendon; *12*, extensor carpi radialis brevis tendon; *13*, extensor digitorum communis and extensor indicis propius tendons; *14*, extensor digiti quinti tendon; *15*, extensor carpi ulnaris tendon.

COMPARATIVE ANATOMY OF THE COLLATERAL LIGAMENTS OF THE WRIST AND OTHER JOINTS

The integrity and stability in such articulations as the knee and interphalangeal joints rests mainly upon the collateral ligaments. The col-

blended and by the extensor tendons themselves. This intimate relation is not present on the flexor surface. The collateral ligaments become taut only at the extremes of abduction-adduction, flexion-extension, and pronation-supination; they are relatively relaxed in all other positions.

In order to determine what the strength and integrity of the wrist joint depended upon, the upper extremities of four human cadavers were dissected, with the following conclusions:

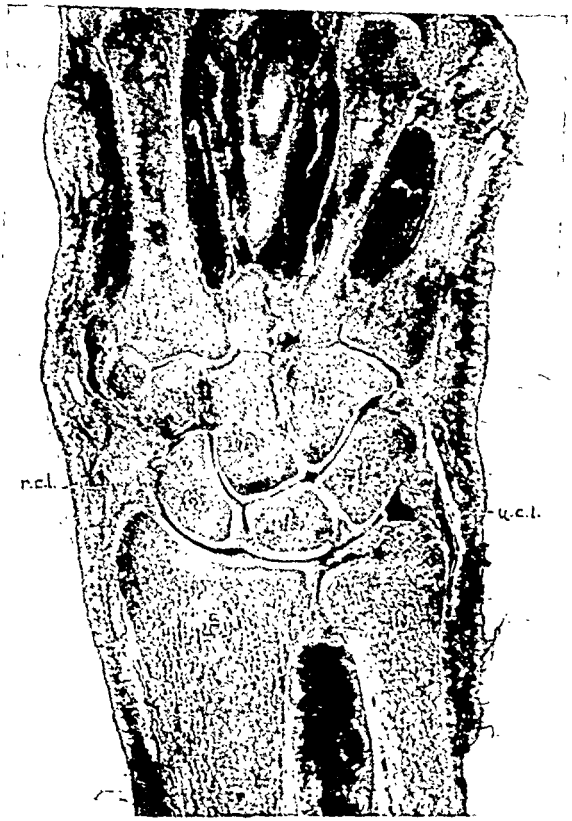


Fig. 1.—Section of hand, wrist, and lower forearm in the frontal plane: *R*, radius; *U*, ulna; *n*, navicular; *l*, lunate; *t*, triangular; *m*, os magnum (capitate); *h*, hamate; *l.m.*, lesser multangular; *g.m.*, greater multangular; *fc*, triangular fibrocartilage; *r.c.l.*, radial collateral ligament; *u.c.l.*, ulnar collateral ligament.

1. The strength of the wrist joint and the prevention of preternatural mobility (anteroposterior and lateral displacement, distraction) are dependent upon (a) the extensor tendons which are intimately related to the posterior surfaces of the radiocarpal and mediocarpal articulations, especially those of the extensor carpi radialis longus and brevis, and, to a less extent, of the extensor digitorum communis (*Fig. 2 a and b*); and (b) the sheaths of these extensor tendons, which intimately blend with and reinforce the thin posterior capsule and radiocarpal ligament (*Fig. 2 a*).

the palmaris longus, by inserting into the bases of the metacarpal bones activate all the joints involved in wrist motion, the radiomeniscocarpal, mediocarpal, and carpometacarpal articulations.

MOVEMENTS OF THE WRIST JOINT

The amplitude of motion is greater in the cadaver than in the living subject, and is greater on passive than on active motion (Ghigi[3]). All movements occur about axes which are distal to the mediocarpal articulation, so that the proximal carpal row and the proximal end of the capitate move in opposite direction to that of the hand in all planes.

The studies of Henke,[4] Cunéo and Veau,[5] and Fick[6] indicate that these axes are not placed so simply as in the frontal plane for flexion-extension and in the sagittal plane for radial and ulnar abduction, perpendicular to each other and traversing the center of the head of the capitate bone. According to Cunéo and Veau, the radiocarpal and mediocarpal joints have common axes which are oblique, directed from anterior and inward to dorsal and outward for the former, and from anterior and outward to dorsal and inward for the latter. Fick believes that these axes are not only oblique in the transverse plane, but also inclined upon a horizontal; i.e., in an oblique plane from below and forward to upward and backward. Radial abduction, therefore, results from flexion of the radiocarpal joint and extension of the mediocarpal joint; ulnar inclination is due to extension of the radiocarpal and flexion of the mediocarpal joints. These opposite movements annul each other to give true lateral motion. Cunéo and Veau also believe that in flexion there must also occur some radial abduction in the radiocarpal joint and some ulnar abduction in the mediocarpal joint, these opposite movements annulling each other to give true flexion; the reverse occurs in extension. This latter contention is not accepted by Fick.

There is much disagreement as to the part played by the radiocarpal, mediocarpal, and carpometacarpal joints in wrist motion, both in anatomic textbooks (Morris,[7] Poirier and Charpy[8]), and in special roentgenographic studies (Wright,[9] Corson[10]). In my own roentgenographic studies I have noted considerable variation in the amplitude of motion, not only in the normal wrists of several subjects, but also in the two wrists of the same subject. An effort is made here, by using the averages of the roentgenographic measurements in several normal cases, to represent accurately the part played by the various units of this joint complex.

I. *Dorsiflexion and Palmar Flexion.*—1. In dorsiflexion, motion in the radionavicular (radiocarpal) joint exceeds that in the lunate-capitate (mediocarpal) joint (52:33°), but motion in the radiolunate (radiocarpal) joint is less than that in the lunate-capitate (mediocarpal) joint (24:33°).

lateral ligaments inhibit extension beyond 180° when they are taut; they relax in partial flexion, permitting some lateral motion, and become taut again in acute flexion. In the knee lateral motion in flexion is inhibited by the anterior expansion of the internal lateral ligament and by the crucial ligaments.[1] In the interphalangeal joints the tautness of the collateral ligaments in extension is augmented by the shape of the articular surface of the phalangeal head which is not a true circle. The ends of the lateral ligaments in this joint lie anterior to the transverse axis, which itself is variable because of the spiral shape of the articular surface.*

In the elbow and ankle joints the collateral ligaments play their role secondarily, since the avoidance of preternatural mobility in these joints depends more upon the accurate adaptation of their bony components. The lateral ligaments are triangular with their bases distalward and are composed of three fasciculi. The axis of the joint lies somewhere between the anterior and posterior bands, so that these fasciculi become tensed in different positions of the joint. Since the trochlea of the humerus is spiral-shaped and not truly circular, and since the ulnar articular surface is widest distally, lateral motion becomes possible in partial flexion of the elbow joint. In the ankle joint, since the superior articular surface of the astragalus is widest anteriorly, lateral motion is present when the foot is plantar flexed.

Unlike the knee and interphalangeal joints which depend for stability and integrity almost entirely upon their collateral ligaments, and the elbow and ankle joints which depend more upon their osseous components than their collateral ligaments, the wrist joint relies for its integrity upon the extensor tendons and their tendon sheaths which so intimately merge with the posterior joint capsule. Its functional efficiency is enhanced by the multiplicity of components that make up its joint complex.

MUSCLES ACTIVATING THE WRIST JOINT

The tendon of the flexor carpi ulnaris muscle, crossing by way of the pisiform bone to the base of the fifth metacarpal bone and hamate hook, the palmaris longus crossing in front of the annular ligament, and the tendon of the flexor carpi radialis crossing the prominent navicular tubercle and the groove of the greater multangular to the bases of the second and third metacarpal bones, lie so far anterior to the transverse axes of the wrist joint that they have a superior functional advantage over the extensors of the wrist joint which hug the distal radial surface closely (Boileau Grant[2]). However, upon this lesser mechanical advantage of the extensor carpi radialis longus and brevis and the extensor carpi ulnaris tendons depends much of the strength of the wrist joint (vide supra) (Fig. 2 *b*). These flexor and extensor tendons, excepting

*The mechanism operative in the metacarpophalangeal articulation is different in that the collateral ligaments are relaxed in extension and taut in flexion due to the eccentric attachment of these ligaments to the metacarpal head. Thus, lateral mobility is present in extension, but diminishes and disappears as flexion increases.

supported by many others,[8, 12, 13] states that in pronation and supination the ulnar head is not fixed but rotates, in a lesser arc, opposite that of the radius. Cathcart[13] has shown that the shoulder joint, as well as the elbow joint, supplements the proximal and distal radioulnar joints in this complex movement.

Pronation (all muscles being removed) is checked in the human cadaver by the (1) posterior radiocarpal ligament, (2) posterior inferior radioulnar ligament, (3) collateral ligaments of the wrist, and (4) tension in the posterior part of the annular ligament of the proximal radioulnar joint. Supination (all muscles being removed) is limited by the (1) anterior radiocarpal and ulnarcarpal ligaments, (2) anterior inferior radioulnar ligament, (3) collateral ligaments of the wrist joint, (4) tension in the anterior part of the annular ligament of the proximal radioulnar joint, (5) interosseous membrane of the forearm, and (6) contact of the ulnar styloid process against the posterior border of the sigmoid cavity of the radius. How important the latter factor is becomes evident in the restriction of this motion in deformities affecting the integrity of the distal radioulnar articulation; e.g., fractures with shortening of either radius or ulna; upward displacement of the radius as follows severe fracture, dislocation or surgical removal of the radial head; disturbances of growth at the distal radial and ulnar epiphyses; and luxation of the ulnar head.

RECURRENT LUXATION AT THE RADIOCARPAL JOINT

Traumatic dislocation of the wrist has been reported frequently, invariably associated with fracture of the adjacent bony structures. This is to be differentiated from those deformities of the wrist in which, as a result of developmental aberration, epiphyseal injury or infection, there is an apparent forward or backward displacement of the hand on the forearm, the radiocarpal and mediocarpal joints remaining intact. Mouchet and Belot[14] report a case of bilateral "snapping wrist," in which the distal carpal row dislocated recurrently and anteriorly on the proximal carpal row, spontaneously on the right side and with passive effort on the left side. To my knowledge there has been no instance of recurring dislocation at the radiocarpal articulation reported in the medical literature.

CASE REPORT.—M. G., a female, first noted a painless deformity of her left wrist at the age of 17 years. There had been no preceding injury or disease of the involved wrist. Her family history and past personal history were negative. The unilateral deformity was diagnosed as an early Madelung's deformity. There were dorsal and lateral curvature of the radius associated with shortening of the radius, anterior deviation of the distal articular surface of the radius so that the hand appeared displaced volarward, dislocation and prominence of the ulnar head dorsally, and "triangulation" of the carpus.[15] Dorsiflexion was limited by the overhanging posterior lip of the distal articular surface; ulnar abduction was limited by the prominent ulnar head.

2. In palmar flexion, motion in the lunate-capitate (mediocarpal) joint exceeds that in both radiolunate (67:18°) and radionavicular (67:49°) radiocarpal joints.

3. Motion in both directions, in the radiocarpal articulation, is greater in the radionavicular than in the radiolunate joints (88:43°).

4. The range of flexion in the wrist joint (radiocarpal, mediocarpal, carpometacarpal) is only slightly exceeded by the range of extension from the neutral position (68:69°), a total of 137°.

II. *Radial and Ulnar Abduction (In Supination).*—1. In radial abduction more motion occurs in the lunate-capitate (mediocarpal) joint than in the radiolunate (radiocarpal) articulation (9:5°).

2. In ulnar abduction motion is equally distributed in both carpal rows (22:22°).

3. The combined range of radial and ulnar abduction is 74°, the amplitude of ulnar abduction being three times that of radial abduction (56:18°).

III. *Radial and Ulnar Abduction (In Pronation).*—1. In radial abduction almost the entire motion occurs in the lunate-capitate (mediocarpal) joint, only a very slight shift occurring in the radiocarpal joint (26:1°) between the radius and lunate bone.

2. In ulnar abduction, motion in the radiolunate (radiocarpal) joint is five times that in the lunate-capitate (mediocarpal) joint (25:5°).

3. The total range of radial and ulnar abduction is 63°, the amplitude in ulnar abduction only slightly exceeding that of radial abduction (34:32°).

IV. *Rotation of the hand on a vertical axis* (45°) augments the range of supination and pronation. It occurs in both radiocarpal and mediocarpal joints and in the arthrodial joints between the individual carpal bones, rotation occurring about the vertical axis of the capitate bone.

V. *Anteroposterior mobility of the hand on the forearm* is only apparent, since on lateral roentgenograms of the wrist no true active or passive displacement occurs. What does occur is dorsiflexion in the radiolunate (radiocarpal) joint and palmarflexion in the lunate-capitate (mediocarpal) joint upon forceful posterior displacement of the hand, while palmar flexion in the radiolunate (radiocarpal) and dorsiflexion in the lunate-capitate (mediocarpal) joints occur on forceful anterior displacement of the hand on the forearm bones.

VI. *Circumduction* is a composite of the four successive movements of flexion, extension, radial and ulnar abduction. It describes an oval, rather than a circle, with its greatest axis anteroposterior.

VII. *Pronation and Supination.*—These movements occur about an axis which, proximally, passes through a variable point near the center of the slightly oval radial head, and, distally, passes between the centers of the distal articular surface of the radius and the ulnar head, closer to the latter. Heiberg's[11] theory, first propounded by Le Comte, and

to the proximal portion, superficial to its previous tendon sheath. The sheath of the extensor pollicis longus tendon was repaired, and the subcutaneous tissue and skin closed in layers (Figs. 3 and 4).

The left wrist was immobilized in plaster of Paris, in neutral position, for three weeks and this was followed by physiotherapy, massage, and exercises to regain motion. When last examined (February, 1940) she had had no recurrence of the clicking sensation. The range of active motion was: 60° flexion, 45° extension, 20° radial abduction, 20° ulnar abduction, and complete pronation and supination. There was no anteroposterior motion, actively or passively.

Discussion.—The recurrent luxation and the preternatural mobility in the radiocarpal articulation were believed due to three factors:

1. An exaggerated radiocarpal joint angle with deficient anterior lip of the distal articular surface of the radius, despite the previous wedge resection performed to correct this deformity.

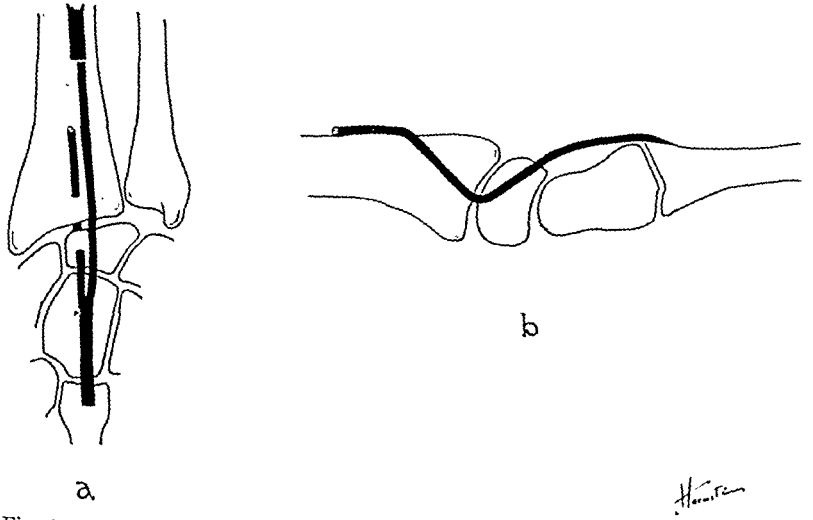


Fig. 4.—Line drawings of specimens shown in Figs. 1 and 2. *a*, Frontal view and *b*, lateral view, showing one-half of the distal stump of the extensor carpi radialis brevis tendon traversing channels drilled through the radius and lunate bone, with the other one-half of the distal stump resutured to the proximal portion of the tendon.

2. Hypotonia of all the joints of both upper extremities, and especially evident in the normal right wrist.

3. The loss of the essential support of the wrist joint (reinforcement of the dorsal radiocarpal ligament and capsule by the extensor tendons and their sheaths) by the shortening of an already foreshortened radius through a dorsal wedge resection at the distal end of the radius, and by the removal of the distal end of the ulna.

The operative procedure employed in this case is based upon the technique of the Nicola operation for recurrent dislocation of the shoulder joint,[16] a ligamentous strut being constructed across the center of the radiocarpal joint. It was appreciated that motion in this joint would thereby become somewhat impaired, since the center of its motion was being transferred from the center of the head of the capitate bone

The deformity was cosmetically improved by the removal of a dorsal wedge at the distal end of the radius in February, 1936, but the patient began to experience pain, especially about the more prominent ulnar head, in May, 1936. She was subjected to a second operation for the removal of the distal three-fourth inch of the ulna, with subsidence of her discomfort. In February, 1938, she began to complain of recurrent episodes of painful swelling of the left wrist and of an annoying painful "click" upon flexion of the left wrist. There were an unusual amount of preternatural mobility of the hand on the forearm present passively and a palpable click in the wrist on flexion beyond 30°. Lateral roentgenograms revealed a recurrent, partial, anterior dislocation of the proximal carpal row on the radius upon flexion of the wrist, with spontaneous reduction on extension. The patient's disability and complaints increased despite periodic splint fixation and intensive physiotherapeutic measures until August, 1939, when she requested a more radical and effective interference. The following operative procedure was employed, after considerable trial on the human cadaver, in preference to an anterior bone block or a radiocarpal fusion, as the simplest means of restoring stability and yet of preserving function and motion in the involved joint.

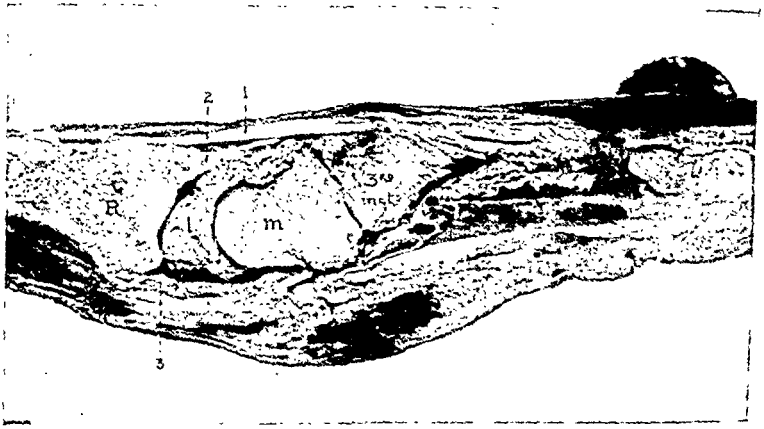


Fig. 3.—Sagittal section of wrist and lower end of forearm: *R*, radius; *l*, lunate; *m*, os magnum (capitate); *3rd met*, third metacarpal; *1*, extensor carpi radialis brevis tendon; *2*, dorsal radiocarpal ligament and dorsal capsule; *3*, volar radiocarpal ligament and volar capsule.

Operation.—A three-inch incision was made on the dorsum of the left wrist extending two inches proximal to and one inch distal to the radiocarpal articulation, and just lateral (radial) to the prominent ridge which separates the tendons of the extensor carpi radialis brevis and extensor pollicis longus. The sheath of the former tendon was incised longitudinally and the tendon was severed two inches above the joint line. By retracting the extensor pollicis longus tendon laterally after partially opening its sheath and by incising the dorsal capsule transversely, a satisfactory view of the radiolunate joint was obtained. The distal stump of the extensor carpi radialis brevis tendon was split into equal halves and one part was roughened and passed through one-eighth-inch drill holes which traversed the lunate bone and the distal end of the radius, penetrating near its center. This maneuver, while it was performed with difficulty on the cadaver, was effected with ease in the patient because of the marked laxity of the tissues in this region. The tendon was sutured under tension, with the wrist in neutral position, beneath two periosteal flaps previously elevated, and this was reinforced with the incised tendon sheath walls. The unused portion of the distal tendon stump was resutured

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to the center of the radiocarpal joint itself, but it was believed (and substantiated postoperatively) that the loss would be compensated for by the motion in the mediocarpal and carpometacarpal articulations. A similar change in the center of shoulder joint motion occurs following the Nicola procedure, but the glenohumeral restriction resulting thereby is so well supplemented by motion in the acromioclavicular and sternoclavicular joints that a complete range of motion is usually restored to the shoulder joint complex. This principle has been employed for habitual anterior dislocation of the distal end of the ulna by Hill,[17] who passes the tendon of the extensor carpi ulnaris through a longitudinal tunnel in the ulnar head.

CONCLUSIONS

1. Dissections of the wrist joints of four human cadavers show that the strength of this joint and the prevention of preternatural mobility are dependent upon the extensor tendons which are closely related to dorsal surface of the radiocarpal and mediocarpal joints and the extensor sheaths which blend intimately with the posterior joint capsule.

2. Roentgenographic measurements of the normal wrists of several subjects reveal that:

a. Palmar flexion occurs mainly in the mediocarpal joint; dorsiflexion occurs mainly between the radius and navicular bone; motion is greater between the radius and navicular bone than between the radius and lunate bone, in both palmar and dorsiflexion; and the combined range of motion in the component joints of the wrist is almost equal in both palmar and dorsiflexion, being slightly greater in the latter.

b. In supination the range of ulnar abduction, which occurs to equal extent in the radiocarpal and mediocarpal joints, is three times greater than that of radial abduction, which occurs mainly in the mediocarpal articulation; in pronation the range of ulnar abduction, which occurs mainly in the radiocarpal joint, and radial abduction, occurring almost entirely in the mediocarpal joint, are almost equal, being slightly greater in the latter.

3. A case of recurring anterior luxation at the radiocarpal articulation, superimposed upon a pre-existing Madelung's deformity of the wrist, is reported and its successful surgical correction is discussed.

I am indebted to Proefssor J. Parsons Schaeffer, Director of the Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pa., for his generous supply of anatomic material.

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New facts have been found since the publication of the article concerning cases where the x-ray showed a fracture of the base of the distal phalanx. On operation in these cases the distal interphalangeal joint and the extensor tendon were exposed through a U-incision as proposed before. In a typical case, the x-ray of which is shown (Fig. 1), a fracture of the base of the distal phalanx shows what could

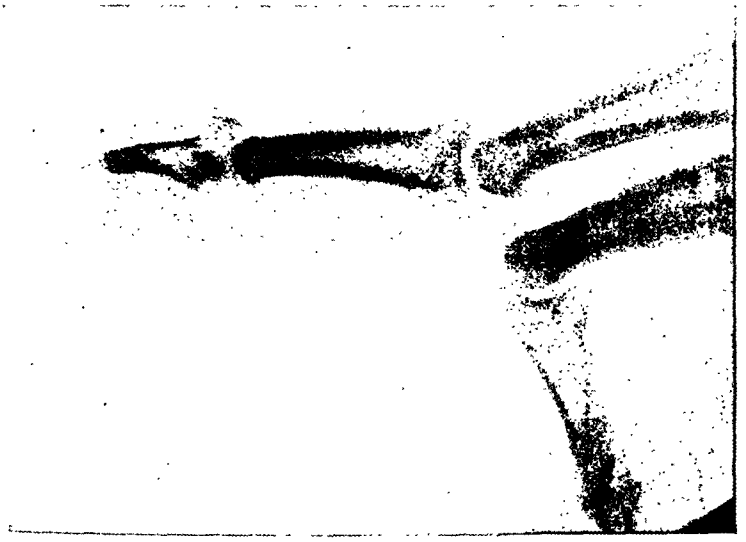


Fig. 1.—X-ray of a fracture of the base of the distal phalanx due to a typical injury by a ball.



Fig. 2.—Photograph of same case as shown in Fig. 1. Typical mallet-finger deformity.

be called an avulsion fracture of the base. Fig. 2 shows the photograph of the same case, which is a typical mallet-finger deformity. On operation in this case the distal interphalangeal joint showed no tear of the extensor tendon and no avulsion of the tendon from its insertion. The examination of this patient, previous to the operation, showed no evidences of swelling or depression of the dorsum of the

MALLET OR BASEBALL FINGER

EMANUEL B. KAPLAN, M.D., NEW YORK, N. Y.

THE deformity which is called mallet or baseball finger has been described and the treatment of it indicated by many authors. The general conception of the cause of this deformity was a rupture of the insertion of the extensor tendon of the finger from the base of the distal phalanx with an accompanying avulsion fracture of this base. The usual treatment was an application of an extension splint to the volar surface of the finger, placing the distal phalanx in hyperextension for a certain period of time; or surgical interference, consisting in a reattachment of the extensor tendon to the base of the distal phalanx through a small L-incision placed over the distal interphalangeal joint of the finger.

The above-described treatment, whether of the first or second type, was found inadequate in many cases, causing a serious disability, especially for people in certain professions.

Multiple observations of these deformities convinced me that the mallet-finger deformity is caused by an injury at different points of the distal part of a finger and probably is very rarely due to an avulsion fracture, as heretofore described.

A systematic roentgenographic study of freshly acquired mallet-finger deformities showed that the evidence of a fracture at the base of the distal phalanx was present infrequently. Furthermore, it showed that, in those cases where the x-ray does not reveal a fracture of the base of the distal phalanx, the examination of the dorsum of the finger reveals an area of acute pain located, not at the base of the distal phalanx, but over the middle of the dorsum of the middle phalanx. This area appears slightly depressed, as if the underlying structures had retracted between the skin and the phalanx; in the area of the distal interphalangeal joint a distinct swelling can be noticed and, of course, the distal phalanx cannot be extended.

In those cases where an x-ray reveals a fracture of the base of the distal phalanx no area of depression or swelling is usually found over the dorsum of the distal or middle phalanx of the finger. In these cases, in addition to flexion, the distal phalanx at times may be found slightly deviated to either the ulnar or radial side.

In a previous article in which a detailed anatomical study of the extensor tendon of the finger was made, the above-mentioned facts were generally described. However, details were not given as they required further study.

Received for publication, November 4, 1939.

passive hyperextension of the distal phalanx was possible, and active hyperextension was absolutely impossible, in spite of the absence of injury. It was, apparently, due to the loss of normal contact of the articular surfaces between the distal and middle phalanges.

In several other cases where an x-ray showed a fracture of the base of the distal phalanx, the surgical exposure of the distal interphalangeal joint showed no avulsion of the extensor tendon. These observations made it possible to conclude that, in the so-called mallet fingers with x-ray evidence of a fracture of the base of the distal phalanx, the deformity is mostly due not to an avulsion of the extensor tendon at the base of the distal phalanx, but to a change in the relation of the articular surfaces of the distal interphalangeal joint. The treatment of these cases may be satisfactorily obtained by application of a hyperextension splint. However, the deformity might be better corrected by a proper exposure of this joint and a gentle replacement of the displaced fractured fragment into its proper location. Fig. 5 shows the

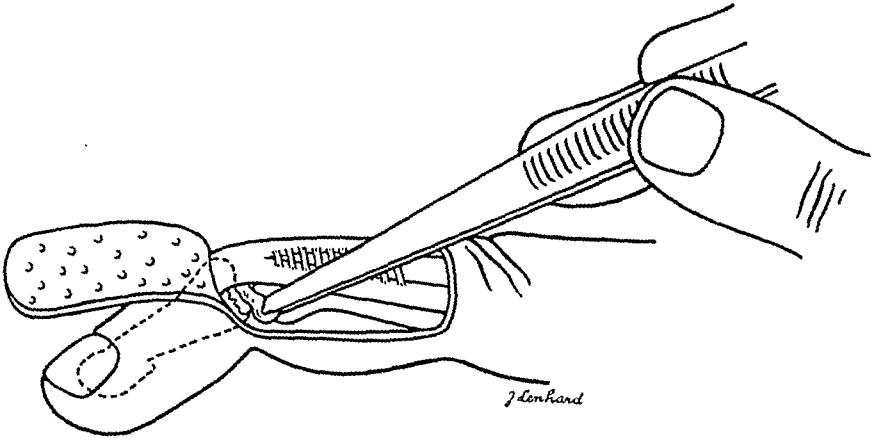


Fig. 5.—Procedure for operative correction of fractures of the base of the distal phalanx.

procedure to be followed. Through a U-incision with a distal base the insertion of the extensor tendon into the terminal phalanx is exposed. The dorsolateral aspect of the distal interphalangeal joint is located and the fractured fragment replaced into position. The terminal phalanx is hyperextended. After ascertaining that the fragment is holding, the U-flap is sewed back in place and an appropriate hyperextension splint used, with the caution of not exerting too much pressure over the dorsum of the finger when the bandage is applied. Four to five weeks of immobilization in this position are sufficient for after-treatment.

In cases where an x-ray of the injured mallet finger does not show any fracture and where the dorsum of the finger shows the pain, swelling, and depression, as previously mentioned, the injury consists in a

finger. Apparently, in this case the mallet-finger deformity was not due to any injury of the extensor, but was produced by a change in relationship between the articular surfaces of the head of the middle phalanx and the base of the distal phalanx.

There exists a balance between the action of the extensors and flexors of the fingers with a preponderance of the flexor action. Normal function with normal extension is possible only in the presence of normal articular surfaces. As soon as the normal relation of the articular surfaces is lost, the preponderance of the flexor is evidenced.

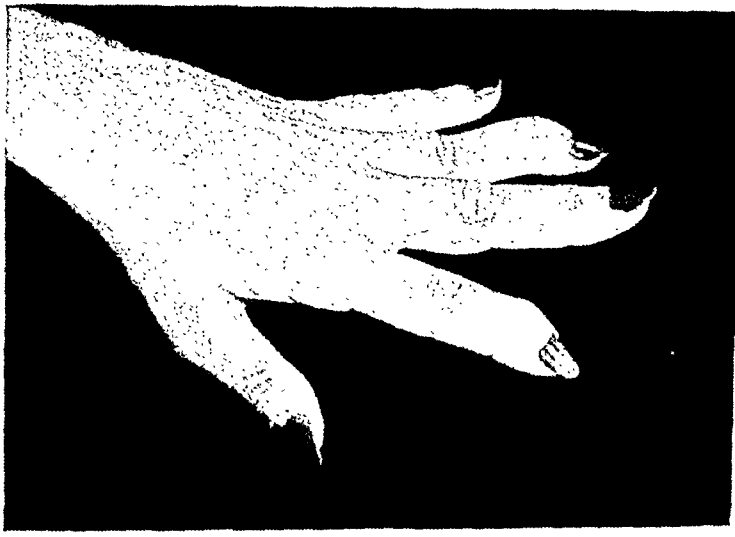


Fig. 3.—Mallet deformity of the index due to arthritis.

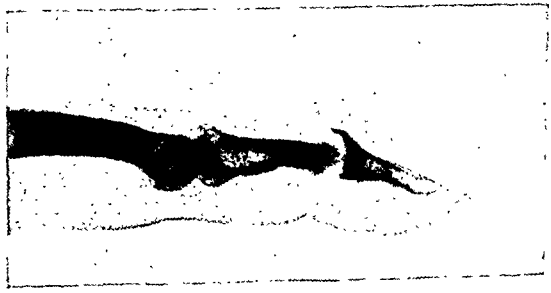


Fig. 4.—X-ray of the same deformity as shown in Fig. 3.

The active extension is then impossible because the normal propping necessary for extension leverage is lost in the distal interphalangeal joint. Fig. 3 illustrates a mallet deformity in which no injury to the finger occurred. The patient was suffering from a destructive type of arthritis of the fingers, the exact nature of which was not established. On x-ray examination (Fig. 4) a destruction of the articular surface of the distal interphalangeal joint could be seen. In this case

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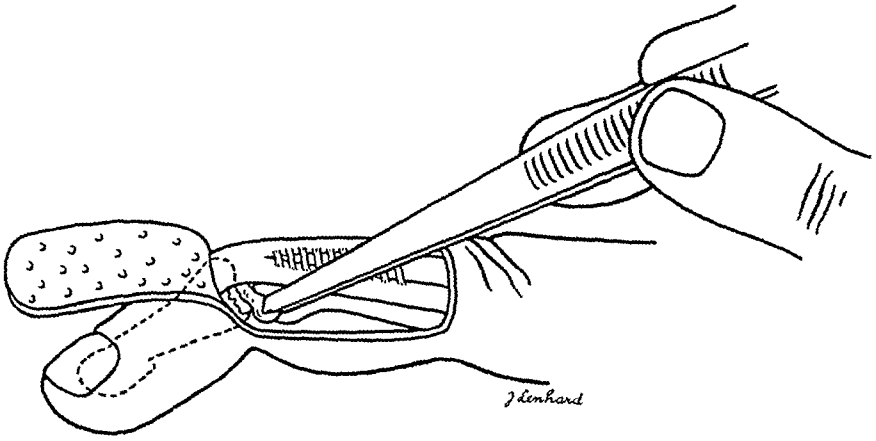


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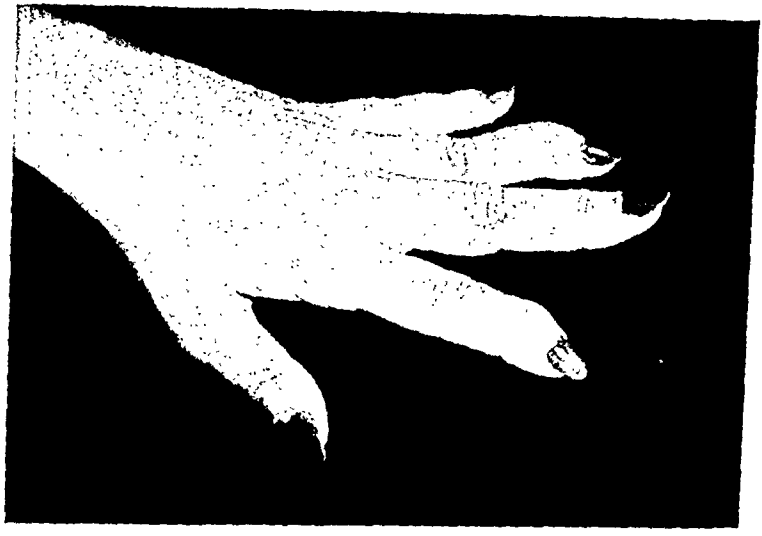


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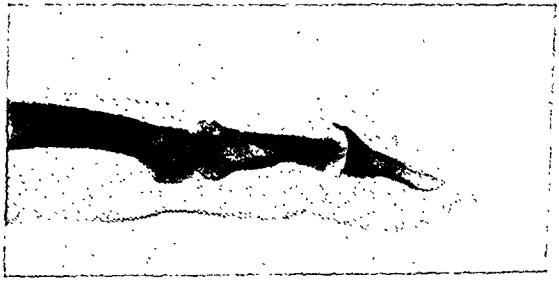


Fig. 4.—X-ray of the same deformity as shown in Fig. 3.

The active extension is then impossible because the normal propping necessary for extension leverage is lost in the distal interphalangeal joint. Fig. 3 illustrates a mallet deformity in which no injury to the finger occurred. The patient was suffering from a destructive type of arthritis of the fingers, the exact nature of which was not established. On x-ray examination (Fig. 4) a destruction of the articular surface of the distal interphalangeal joint could be seen. In this case

applied directly to the end of the terminal phalanx, the base of the terminal phalanx is fractured in correspondence with the angle of application of force, thus producing a change of the normal contact of the articular surfaces (Fig. 9).

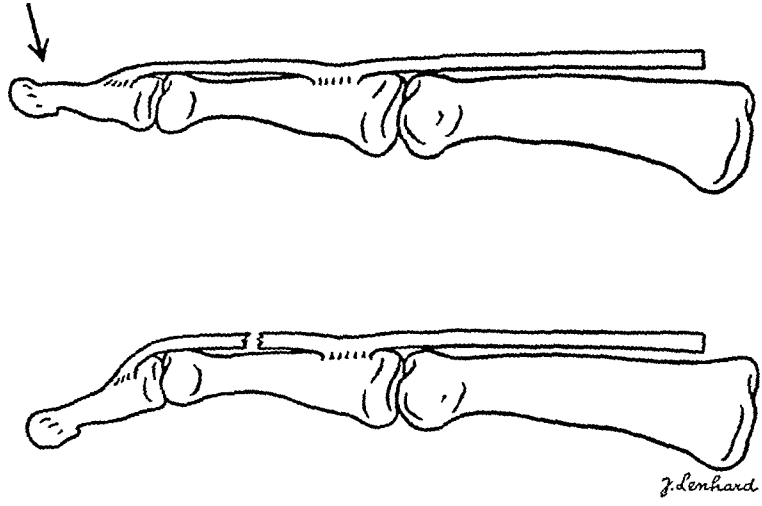


Fig. 8.—Mechanism of the rupture of the extensor tendon.

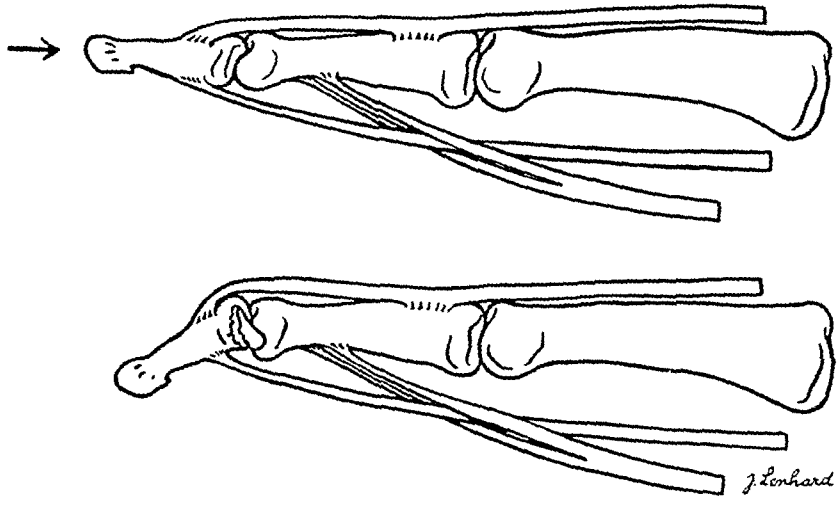


Fig. 9.—Mechanism of fracture of the base of the distal phalanx.

The U-incision on the dorsum of the finger has the following advantages: It gives a very much better exposure of the dorsum and it eliminates adhesions over the distal interphalangeal joint which occur when the incision is placed over the distal interphalangeal joint. The avoidance of these adhesions is of great importance. The extensor apparatus of the dorsum of the finger has a gliding motion, when the finger passes from extension to flexion and vice versa. The gliding

rupture of the extensor tendon which occurs not at its insertion at the base of the distal phalanx, but over the dorsum of the middle phalanx. The rupture follows an irregular, more or less oblique line, involving the two prolongations of the extensor tendon and the structure between them (Fig. 6). The operative procedure for these cases has been described in a previous article and is illustrated in Fig. 7. It is believed that, while the hyperextension splint in certain cases of a fractured base of the terminal phalanx may be satisfactory, the hyperextension splint in the treatment of a rupture of the extensor tendon is inadequate and is probably responsible for failures in a number of instances. The rupture of the extensor tendon may be corrected apparently only by a suture of the tendon as described in the previous article.

Real avulsion fractures of the terminal phalanx are probably great rarities, although they were described as the usual type.

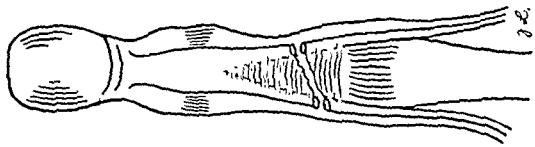


Fig. 6.—Schematic representation of the location of extensor tendon tear in certain mallet-finger deformities.

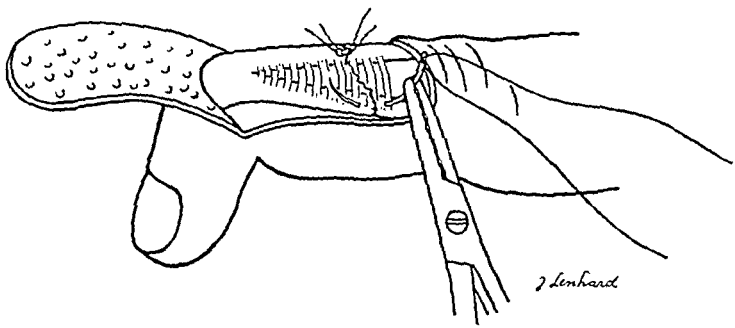


Fig. 7.—Operative correction of extensor tendon tears.

The mechanism of the two types of mallet-finger deformities due to injury is apparently not complicated. In Fig. 8 the mechanism of rupture of the extensor tendon producing this deformity is illustrated, the finger being in hyperextension and the extensor tendon being tense with a pulling force directed proximally. If a force is applied directly to the dorsum of the terminal phalanx of the hyperextended finger, the rupture does not occur at the insertion of the extensor apparatus to the terminal phalanx, neither at the point of insertion at the base of the middle phalanx, but in the area between these two fixed points, over the dorsum of the middle phalanx. If the force is

an avulsion fracture of the base of the terminal phalanx is doubtful. The probable cause is either a rupture of the extensor tendon apparatus over the dorsum of the middle phalanx or a fracture of the base of the terminal phalanx without any injury to the extensor tendon. The treatment in the first type is a suture of the torn structures as described previously. The treatment in the second type is a hyperextension splint, as has been used extensively, or an operative procedure which may improve the results.

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motion is only about 1 or 2 mm. and it is not due to the elasticity of the extensor apparatus but to the free play of the fibers which unite the extensor apparatus to the sides of the proximal interphalangeal joint. The slightest interference with this gliding motion by adhesions, be it at the insertion over the distal interphalangeal joint, or at the proximal interphalangeal joint, produces a corresponding shortening of the portion of the extensor apparatus between the distal and proximal interphalangeal joints. This shortening interferes with the normal balance between the extensor and the flexor tendons of the finger, with a subsequent development of a hyperextension of the prox-



Fig. 10.—Typical deformity of the ring finger due to postoperative adhesions over the dorsum of the distal interphalangeal joint.

imal interphalangeal joint. It was observed that in those cases of mallet-finger deformities in which an incision was made over, or in the nearest proximity of the dorsum of the distal interphalangeal joint, a deformity invariably developed which consisted in a hyperextension at the proximal interphalangeal joint and a persistence of the mallet-finger deformity (Fig. 10). The U-incision permits a wide exposure of the distal interphalangeal joint and eliminates a scar involving the skin, tendon, and the underlying periosteum. In all the cases so far observed, not a single instance of necrosis of the flap was noticed.

The purpose of this study is to show that the generally accepted view which considers the cause of the mallet-finger deformity to be

If an adequate collateral circulation is found to be present preoperatively, one certainly cannot be assured that it will be maintained postoperatively because the sympathetic nerves controlling the caliber of the vessels as well as the volume flow through them are intact. The reflex arc, therefore, is capable of setting up vasomotor spasm of the vessels from the stimulation of the nerves by surgical trauma, as well as by the irritation produced by sterile or septic inflammatory exudations following operation. The collateral circulation then becomes rapidly deficient, which not infrequently results in gangrene of the tissues distal to the aneurysm. This postoperative vascular spasm of the collaterals occurs in both arterial and arteriovenous aneurysms.

There are several anatomical sites where the collateral circulation is normally deficient and must always be tested and developed before the main artery can be obliterated. These locations are as follows: popliteal, internal carotid, common femoral, common and external iliacs. Therefore, aneurysms occurring in these areas have, as a rule, an inadequate collateral circulation to the tissues distal to the aneurysm. In treating aneurysms occurring in the areas of collateral deficiencies, the collateral circulation must not only be developed but sustained in order that gangrene will not occur.

The efficiency of the collateral circulation can be determined preoperatively by the test devised by Dr. Matas. The test consists of rendering the extremity ischemic by the application of a Martin rubber bandage from the toes to above the aneurysm, application of the Matas compressor to the main artery above the bandage, removal of the rubber bandage, and notation of the time required for the ischemic foot or hand to regain its pink color. This test is indispensable from the standpoint of determining the presence of a collateral circulation. Having determined that sufficient collateral vessels exist, the next and the most important procedure is to develop and sustain an adequate collateral circulation with sufficient blood flow that will nourish and maintain normal metabolism of the tissues of the extremity. If it is determined preoperatively that a fair to good collateral circulation is present, there is no assurance, however, that it will be maintained postoperatively as long as the involved vessels are under the control of the sympathetic nervous system.

In order that the collateral circulation may be developed rapidly, the collateral vessels permanently dilated and an increased volume flow of blood pass through the vessels, and the increased blood flow and vessel dilatation be maintained, the entire vascular tree of the extremity must be completely dissociated from its sympathetic nerve control. The preoperative removal of the sympathetic control of the vascular tree of an extremity not only produces vasodilation of the collateral vessels, and an increase in the blood volume flow, but prevents the development of postoperative vasomotor spasm of the vessels

Editorial

The Development of the Collateral Circulation in Peripheral Arterial Aneurysms by Sympathetic Block

THE final result following the surgical treatment of the various organic diseases of the peripheral arteries depends upon the presence of a collateral circulation to maintain continuity of tissue and life of the extremity when the main vessel is obstructed. Conversely, if there is a failure of development of an adequate accessory circulation in the presence of progressive organic disease, there is a partial or complete loss of the extremity because of gangrene.

As the majority of arterial aneurysms of the peripheral arteries can be classed as systemic or traumatic organic diseases, the collateral circulation distal to the aneurysm is of paramount importance for the successful treatment and for the maintenance of a normal functioning extremity.

There are anatomic areas in which aneurysms of the peripheral arteries are likely to occur, the most common sites being the popliteal, femoral, axillary, and carotid vessels. Also, the subclavian may be considered a peripheral vessel because the blood supply to the upper extremity is dependent upon its patency. The majority of arterial aneurysms of the peripheral arteries are traumatic in origin, with the exception of the popliteal, subclavian, and carotid. The last are due, in the majority of instances, to systemic disease, of which syphilis and arteriosclerosis play the most important roles.

That injury to an artery, either by mechanical means or by intrinsic disease, produces an irritation of the vascular sympathetic nerves (vasoconstrictors and dilators), which irritation results in vasomotor irritability and spasm of the vascular tree, is a well-known clinicopathologic fact. Therefore, in all arterial aneurysms of the peripheral arteries there is a decrease in the normal flow of blood through both the collaterals and main arterial stem.

The successful treatment of all aneurysms of the peripheral arteries with few exceptions depends upon the obliteration of the aneurysmal dilatation of the artery and the maintenance of a normal limb distal to the aneurysm by an adequate and sustained collateral circulation. The obliteration of the aneurysm is accomplished either by proximal polar ligation of the main artery, with secondary clotting of the sac, or by the obliteration of the aneurysm sac by the intrasaccular suture of Matas. Regardless of the type of operative procedure used in the surgical cure of the aneurysm, the maintenance of a normal functioning limb depends upon the development of an adequate and sustained collateral circulation.

also be used; however, we prefer the anterior approach devised by Leriche and modified by DeBakey.

In the surgical clinic at Tulane University we have used this procedure in over fifteen cases of both arterial and arteriovenous aneurysms of the peripheral arteries. The collateral circulation has been rapidly developed and maintained. The aneurysm sac decreased in size and intrasaccular clotting occurred in all of the cases. Included in our series are aneurysms of the brachial, common iliac, external iliac, common femoral, femoral, profunda femoria, and popliteal. The aneurysms have been of both the arterial and arteriovenous types. The ages of the patients ranged from 12 to 64 years.

Gangrene has not occurred in a single case, even though two patients with popliteal aneurysms had postoperative infection of the wound. The foot and the extremity on the side operated upon maintained not only an elevated surface temperature, but a normal color. This has been demonstrated in all the cases. The results obtained in these cases justify a continuance of this method of producing and maintaining an adequate collateral circulation as a preliminary to the surgical treatment of all cases of aneurysms of the peripheral arteries.

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—*Mims Gage, M.D.*
New Orleans, La.

secondary to operative trauma. If this postoperative vasomotor spasm of the collateral vessels is sufficiently prolonged, thrombosis and secondary gangrene may occur.

Thies has definitely proved experimentally that there is increase of blood volume flow through the arterial tree of the hind leg of the dog, following the removal of the lumbar sympathetic ganglionated chain and ligation of the femoral artery on the same side. This has also been demonstrated clinically in diseases of the peripheral vessels, such as Buerger's, Raynaud's and arteriosclerosis. There exists in two of these diseases an organic obliterative arteritis of the main arterial stem with concomitant vasospasm of the vessels of the collateral circulation. In removing the sympathetic control of the entire arterial tree of an extremity by ablation of the sympathetic ganglionated chain, either by mechanical or chemical means, there results an immediately increased blood volume flow through the vasodilated collaterals which is sustained. If this method of treatment is induced early in the diseased states noted above, the normal color of the extremity returns, the surface temperature is consistently elevated, gangrene is prevented, and the associated pain is relieved in the majority of cases. However, if the collateral vessels are involved by the progression of the disease and their caliber greatly diminished or obliterated, gangrene with complete or partial loss of an extremity becomes inevitable.

In 1934 it was suggested[1] that the sympathetic nerves supplying the arterial tree of an extremity be interrupted by surgical removal or alcoholic destruction of the sympathetic ganglia, in order that an adequate collateral blood supply would not only be produced but maintained, preoperatively as well as postoperatively, following the surgical treatment of all arterial aneurysms of the peripheral arteries. The alcoholic destruction of the ganglia is preferable to surgical removal in the majority of cases.

For aneurysms of the lower extremity involving the iliac, common femoral, femoral, and the popliteal arteries, the first, second, and third lumbar sympathetic ganglia on the same side as the aneurysm should be injected with 95 per cent alcohol. In the upper extremity, for the subclavian, axillary, and the brachial aneurysms, the stellate ganglion and upper three dorsal sympathetic ganglia should either be removed surgically or repeatedly injected both preoperatively and postoperatively with 1 per cent novocain. This same procedure should also be used for carotid and intracranial aneurysms. Alcoholic injection of the stellate ganglion is contraindicated due to the high incidence of alcoholic neuritis of the brachial plexus which results from diffusion of the injected alcohol. In the lumbar region the posterior approach of Lundy is used to inject the lumbar sympathetic ganglia. For the stellate and upper three dorsals the posterior approach of Lundy can

(2) fractures of the nose; (3) fractures of the zygomatic bone and zygomatic arch; (4) fractures of the maxilla; (5) miscellaneous multiple fractures.

ANATOMY

The zygomatic bone (old terminology, malar) lies in the most prominent part of the cheek and is therefore often referred to as the cheek bone. It articulates anteriorly with the zygomatic process of the maxilla, posteriorly with the zygomatic process of the temporal bone by which junction the zygomatic arch is formed; and superiorly it unites with the great wing of the sphenoid and the frontal bone. The anterior-superior portion of the bone forms the lateral orbital border and a portion of the floor of the orbit. In structure the zygomatic bone is compact with little spongy tissue. Assisted by the zygomatic process of the temporal bone, it forms the buttress which supports the maxilla and the lateral wall of the orbit. Beneath the zygomatic arch is the coronoid process of the mandible, an anatomical fact worthy of notice. A depressed fracture of the zygomatic arch or of the zygoma by mechanical interference may prevent normal movements of the mandible.

PRODUCTION OF FRACTURES

Breaks in the continuity of these bones are produced by a variety of agents. The injuries were produced in the series reported here by fist blows (13 cases), automobile accidents (10 cases), blackjack (1 case), football (1 case), fall (1 case). These fractures occur in by far the largest majority of cases as single fractures; i.e., only infrequently are other facial bones, with the exception of the maxilla, involved.

The area in which fractures occur is illustrated in Figs. 1 and 2. It should be noted that the zygomatic bone does not always separate from the maxilla at the suture line. Naftzger (1928) investigated the experimental production of these fractures. In Naftzger's series, which was conducted on cadavers, the maxillary sinus was found to be involved each time the zygomatic bone was fractured. It is evident that, because of the thin anterolateral wall of the antrum, fractures in this region occur most readily by a crushing in of this structure. Thus, a hard, moving object, such as a fist, applied directly to the cheek bone will produce an impacted fracture of the zygomatic bone, crushing in the lateral antral wall, separating the frontal suture, and dropping the orbital floor. There may be buckling outward of the zygomatic arch due to a posteriorly applied force, or the zygomatic arch may be intact, except for the junction with the zygomatic bone. The zygomatic arch alone may be fractured by a directly lateral force, separating from the zygomatic bone at its sutural junction. Since,

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

FRACTURES OF THE ZYGOMATIC BONE

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FRACTURES of the zygomatic bone and the zygomatic arch have shown a marked increase in frequency in the past decade. This communication deals with a study of twenty-six cases of fracture of the zygomatic bone or zygomatic arch, observed and treated at the Cook County Hospital.

INCIDENCE

Matas (1896), reviewing the early literature on the incidence and treatment of these fractures, estimated the incidence of fractures of the zygomatic bones on the basis of hospital experience between the years 1879 to 1896. During this period of seventeen years, 111,802 patients were admitted to the Charity Hospital of New Orleans. This group included 5 fractures of the zygomatic arch or the zygomatic bone, giving an incidence of 1 fracture in every 22,360 hospital admissions. Speed (1916) reported "in Cook County Hospital in the last eight years there have been 17 fractures of the malar bone." During the period 1909 to 1916, approximately 171,000 patients were admitted to the Cook County Hospital. This provides an incidence of 1 fracture of the zygomatic bone to every 10,000 hospital admissions. In the year 1939, 23 fractures of the zygomatic bone and zygomatic arch have been seen and treated at Cook County Hospital. Therefore, an incidence of 1 fracture of the zygomatic bone or zygomatic arch to about 3,040 hospital admissions pertains at the present time. This represents an increase of 700 per cent in the incidence of these fractures since the time of Matas' report and 300 per cent since 1916. The reasons for the increase in the incidence of these fractures are not readily apparent, since, as will be shown later, most of the fractures in this series resulted from fights and fist blows. Automobile injuries, which are usually considered an important factor in the production of these fractures, accounted for 40 per cent of the cases in this series. In our experience fractures of the facial bones occur in this approximate order of frequency: (1) fractures of the mandible;

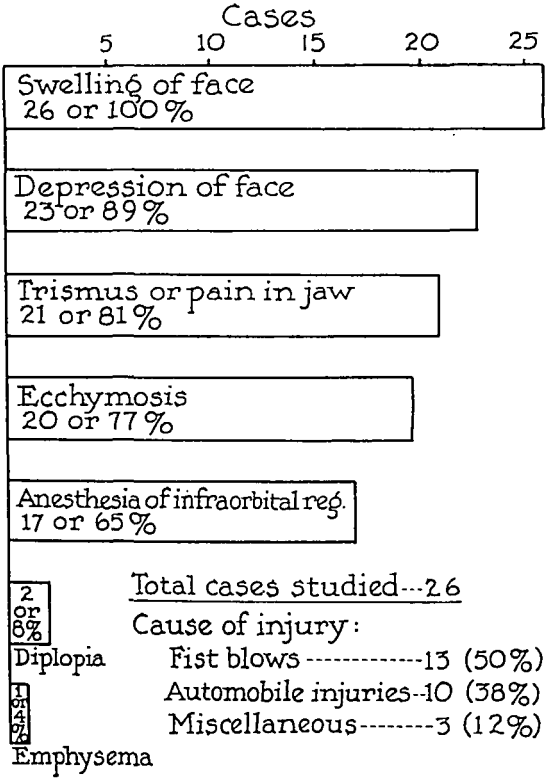


Fig. 3.

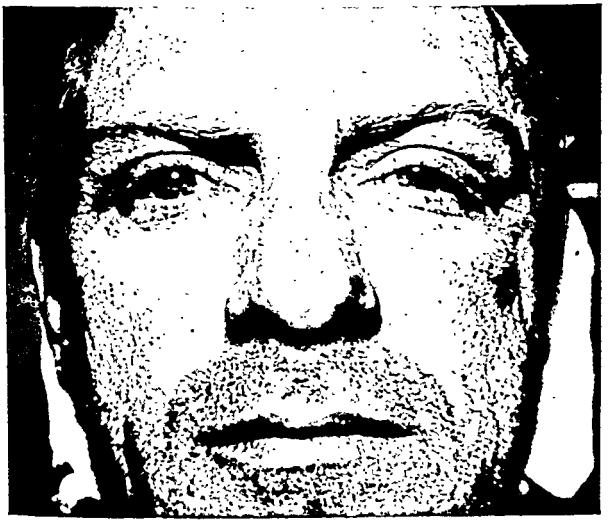


Fig. 4.—Characteristic flattening of the left malar eminence. Note also narrowing of the palpebral fissure on the left, due to changes in the orbital structure. This patient had diplopia which was completely relieved by elevation of the zygomatic bone and orbital floor.

anatomically, the zygomatic arch is formed in part by the zygomatic bone, it is evident that a depressed fracture of the zygomatic bone usually is associated with a depressed fracture of a portion of the zygomatic arch. In the series reported here, the zygomatic bone and zygomatic arch were involved in 21 cases and the zygomatic arch alone involved in 5. Of this group, 25 were males and 1 was female.

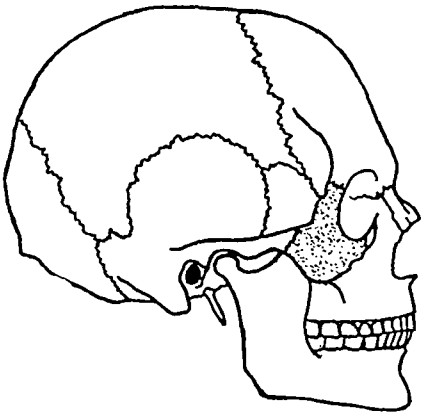


Fig. 1.

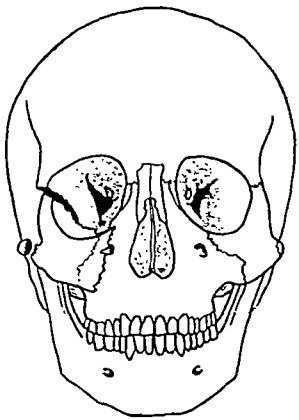


Fig. 2.

Fig. 1.—Lateral view of skull, showing zygomatic bone (stippled) and zygomatic process of the temporal bone. Note coronoid process of mandible underneath zygomatic bone and arch.

Fig. 2.—Front view of skull with depressed fracture of right zygomatic bone. Note that separation does not occur at the suture line, but at the thinnest portion of the antral wall with consequent crushing.

CLINICAL SIGNS AND SYMPTOMS

In Fig. 3 are presented the outstanding signs and symptoms found in the 26 patients studied in this series. Thus, all of the patients in this series presented swelling of the face on the involved side. Swelling may obscure signs of fracture; but early, before swelling occurs, or late, after swelling has receded, it may be seen that the involved side of the face is usually flattened due to loss of the normal prominence of the zygomatic bone (Fig. 4). Three of the patients had no obvious depression of the face, but they did complain of interference with movements of the jaw. Fractures, however, were demonstrated on x-ray examination. Twenty-one of the patients studied complained of moderate or marked interference with the movements of the mandible. This varied from some restriction of full opening of the mouth to complete inability to separate the teeth. The interference with movements of the mandible was particularly marked in those fractures of the zygomatic arch where there was a depression of the bone and mechanical interference with the coronoid process of the mandible. That this interference in movement is not due entirely to muscular trismus is indicated by the fact that immediately after elevation of the fragments much fuller motion

tour of the junction of the zygomatic bone and maxilla. Traumatic swelling may obscure all these findings, but early and late cases will be readily diagnosed. Fractures of the facial bones are frequently difficult to demonstrate unless particular care is taken with the position of the patient during x-ray examination (Fig. 5). A satisfactory x-ray position has been described by Gillies, Kilner, and Stone (1927) for the visualization of the zygomatic arch. Ennis (1939) describes a good position for the visualization of the zygomatic bone. In general, the Waters position, as used for sinus radiography should be adequate to demonstrate these fractures.



Fig. 5.—X-ray showing fracture of the right zygomatic bone.

TREATMENT

The care of these fractures has for its objectives the restoration of facial symmetry and, if they exist, the correction of diplopia and the relief of any interference to mandibular movements. Early treatment is essential for the best care of these fractures, for healing is so rapid that after two weeks it may be difficult to reduce the deformity without resorting to surgical separation of the bony junctions. All possible approaches have been proposed to accomplish these effects. The early writers were conservative in their treatment of simple fractures with some evidence that in certain cases of fracture of the zygomatic arch the displacement and deformity and functional disturbances connected with mastication were finally overcome by natural muscular pull without operative interference (Agnew [1878], Garland [1885], Prewitt [1886], Clark [1887], Hamilton [1894]). The rationale of this ob-

of the mandible is attained. Ecchymosis of the periorbital tissues was observed in 20 of the patients and several also presented with subconjunctival hemorrhage. Anesthesia of the upper lip and lateral surface of the nose, an area innervated by the infraorbital branch of the superior maxillary division of the trigeminal nerve, was present in 17 of the patients studied. This anesthesia is associated with injury to the nerve as it leaves the infraorbital foramen in the maxilla. Diplopia may or may not be present when the orbital floor is distorted by a mass depression of the zygomatic bone. Changes in the orbital tension and attachments and tension of the extraocular muscles are responsible for the diplopia so produced. Two patients in this series complained of double vision which was entirely relieved by elevation of the zygomatic bone and restoration of the orbital floor to its normal position. Permanent impairment of vision is only likely to occur if the change is due to injury or paralysis of one of the extraocular muscles. Because of the dropping of the orbital floor and changes in the orbital tension, narrowing of the palpebral fissure may be found on the involved side. As the floor is elevated and the optic globe pushed forward, this will be corrected. This change can only be noted in those late cases where the initial swelling and reaction have subsided. Surgical emphysema was seen in one case in this series. This was probably due to a tear in the mucous membrane of the antrum with subsequent subcutaneous inflation of the tissues. This also cleared promptly with no untoward sequelae. Since there is usually a crushing in of the lateral antral wall in conjunction with fractures of the zygomatic bone, one of the most common signs is unilateral bleeding from the nose, produced by a discharge of blood from the maxillary ostium. Crepitus can rarely be elicited in these fractures because so many of them are impacted into the maxillary sinus.

DIAGNOSIS

The diagnosis may usually be readily made by the history, inspection, palpation, and x-ray examination. Inspection, if made early before swelling has occurred, will indicate the characteristic flatness due to loss of the malar prominence or the arch of the zygoma. When only slight depression has occurred, this will not be evident. Palpation of both sides of the face should be made systematically. The orbital rims should be outlined with the fingers. Separation of the zygomatic bone from the orbital process of the maxilla may be noted as a loss in continuity of the orbital rim, and detachment of the zygomatic bone from the frontal bone likewise may be noted. Palpation of the zygomatic arch will indicate whether or not a depression is present. Interference with opening of the mouth is confirmatory evidence of depression of the zygomatic arch. Palpation in the mucobuccal fold within the mouth likewise will indicate a change in con-

arch. The silk acts as a carrier for a silver wire which is then attached and pulled through to form a wire sling about the bone. By this means traction can be exerted outward and the bone pulled into position. The bone is prevented from relapsing to its previous position by twisting the wire over a glass microscope slide laid over the arch on a piece of iodoform gauze. Other direct approaches have been proposed. Thus, towel clips and cowhorn dental forceps with which to grasp the bone from the outside have been proposed (Manwaring [1913], Gill [1928]). Moorhead (1917) recommends traction on the bone by a hook or other device passed beneath the depressed bone. This method has recently been reintroduced by Patterson (1935), who uses a heavy curved tenaculum passed under the bone through a small skin incision, pulling the fragments outward until reduction occurs. Similarly, Roberts (1928) makes a small incision over the bone and passes a special corkscrew-like instrument through the bone, and, using this as traction, manipulates the fragment into place. Ivy and Curtis (1931) employ a modification of this method with success. They make a skin incision over the depressed bone, drill a small hole into the bone, and insert either an ordinary screw hook or a dental screw porte into the bone which may be thus manipulated. Less direct approaches have been proposed by Lothrop (1906), who makes an incision into the mucobuccal fold on the involved side, opens the antrum in the canine fossa as through a Caldwell-Luc approach, cleans the maxillary sinus of bone fragments and blood clots, and elevates the depressed malar bone by a sound introduced into the antral cavity. Gauze is then packed into the antrum to provide support for the fractured bone. The pack is removed in five to ten days. Shea (1931) and Watkins (1937) use a similar method of treatment except that an intranasal antral approach is used. Keen (1909) recommends reduction by inserting a heavy blunt instrument under the zygomatic process of the malar bone through the mouth, thereby lifting the fragments into place. This method has been reintroduced by Straith (1937). Gillies, Kilner, and Stone (1927) indicated another indirect approach which is a classic of applied anatomy. An inch-long incision is made in the hairline superiorly and anteriorly to the ear, dissecting down to the temporal fascia through which a small incision is made. Through this opening an instrument may now be passed directly downward and forward under the zygomatic bone which can then be levered into a normal position. Any, and perhaps all, of these methods suffice for the treatment of early uncomplicated cases and may be satisfactorily used, for here sufficient comminution usually exists to make possible the retention of the fragments once they are elevated. Simple elevation of the bones, provided they will stay in the reduced position, is sufficient to treat the majority of these fractures, but some difficulty has been experienced in maintaining the position of the reduced fracture in late or neglected cases. For

servation is, apparently, that, when the jaws are at rest, the distorted pull of the masseter muscle which arises from the inferior and deep portions of the zygomatic arch will tend to restore the fractured bone to its normal position. Duverney in the first case reported is said to have restored a depressed fracture of the zygomatic arch by digital manipulation from within the mouth. Many later writers contradict

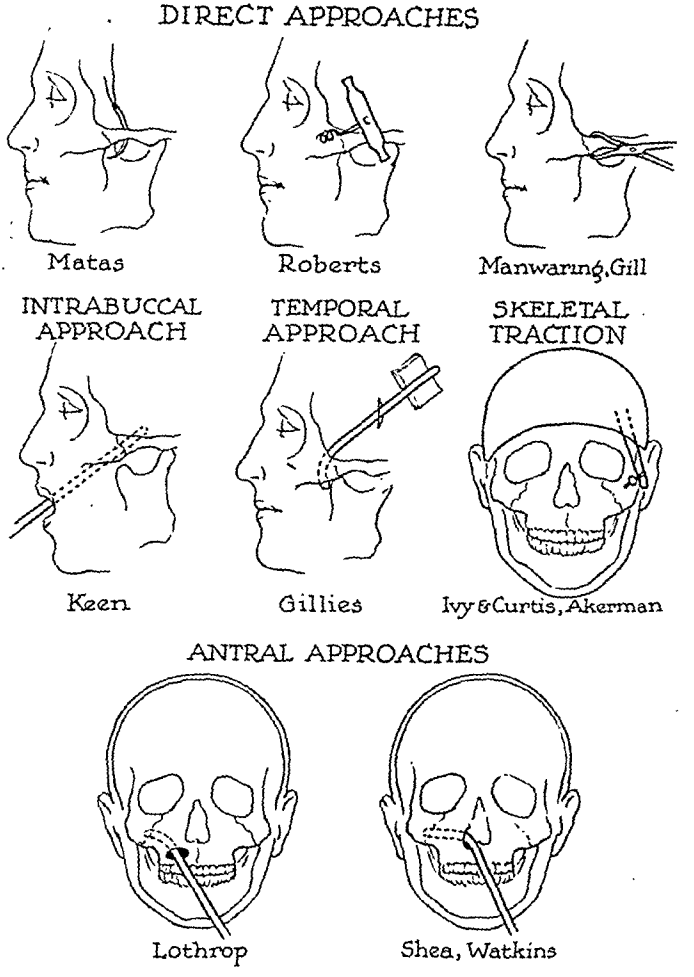


Fig. 6.

this experience. Unless the fracture is a bowing out of the fragments which can thus be pushed into place, it is evident that all dynamic forms of treatment must evolve upon the principle of open reduction. Matas first proposed the use of wire traction (Fig. 6). By his method, described for the treatment of depressed fractures of the zygomatic arch, a large, curved Hagedorn needle is threaded with heavy silk and passed through the skin under the zygomatic arch and brought out over the

arch. The silk acts as a carrier for a silver wire which is then attached and pulled through to form a wire sling about the bone. By this means traction can be exerted outward and the bone pulled into position. The bone is prevented from relapsing to its previous position by twisting the wire over a glass microscope slide laid over the arch on a piece of iodoform gauze. Other direct approaches have been proposed. Thus, towel clips and cowhorn dental forceps with which to grasp the bone from the outside have been proposed (Manwaring [1913], Gill [1928]). Moorhead (1917) recommends traction on the bone by a hook or other device passed beneath the depressed bone. This method has recently been reintroduced by Patterson (1935), who uses a heavy curved tenaculum passed under the bone through a small skin incision, pulling the fragments outward until reduction occurs. Similarly, Roberts (1928) makes a small incision over the bone and passes a special corkscrew-like instrument through the bone, and, using this as traction, manipulates the fragment into place. Ivy and Curtis (1931) employ a modification of this method with success. They make a skin incision over the depressed bone, drill a small hole into the bone, and insert either an ordinary screw hook or a dental screw porte into the bone which may be thus manipulated. Less direct approaches have been proposed by Lothrop (1906), who makes an incision into the mucobuccal fold on the involved side, opens the antrum in the canine fossa as through a Caldwell-Luc approach, cleans the maxillary sinus of bone fragments and blood clots, and elevates the depressed malar bone by a sound introduced into the antral cavity. Gauze is then packed into the antrum to provide support for the fractured bone. The pack is removed in five to ten days. Shea (1931) and Watkins (1937) use a similar method of treatment except that an intranasal antral approach is used. Keen (1909) recommends reduction by inserting a heavy blunt instrument under the zygomatic process of the malar bone through the mouth, thereby lifting the fragments into place. This method has been reintroduced by Straith (1937). Gillies, Kilner, and Stone (1927) indicated another indirect approach which is a classic of applied anatomy. An inch-long incision is made in the hairline superiorly and anteriorly to the ear, dissecting down to the temporal fascia through which a small incision is made. Through this opening an instrument may now be passed directly downward and forward under the zygomatic bone which can then be levered into a normal position. Any, and perhaps all, of these methods suffice for the treatment of early uncomplicated cases and may be satisfactorily used, for here sufficient comminution usually exists to make possible the retention of the fragments once they are elevated. Simple elevation of the bones, provided they will stay in the reduced position, is sufficient to treat the majority of these fractures, but some difficulty has been experienced in maintaining the position of the reduced fracture in late or neglected cases. For

this reason Lothrop's method, opening the antrum through a Caldwell-Luc approach and holding the elevated bone in place with iodoform gauze, has been used in some cases in this series. In two of the patients so treated, it became necessary to provide intranasal drainage for the antrum because of the subsequent sinus infection. These patients then responded satisfactorily to further care. Ordinarily, the method of treatment followed is to reduce the fracture either by Gillies' method or by simply elevating the fragment through a small incision in the buccal fold as described by Keen. In some of the cases when the bones did not stay in place, the antrum was opened through a Caldwell-Luc approach and iodoform gauze treated with compound tincture of benzoin packed into it to hold the bones in position. We object to opening and packing the sinus on theoretical grounds as a poor surgical procedure. For this reason we have more recently used the methods of external traction as proposed by Ivy and Curtis (1931) and Akerman (1938). Through a small one-half-inch incision over the depressed area, a hole is drilled into the zygomatic bone, and an inch-long screw eye turned into the drill hole. The skin wound is closed with horsehair. A plaster headcap is fashioned after the manner of Seogin (1928) incorporating a side arm of heavy wire. Elastic traction supplied by rubber bands is passed from the screw eye to the wire extension. Such traction over a period of four to seven days will usually pull the bone in the desired position and retain it there. The obvious objection to external traction is the additional scarring of the face it produces and the necessity for the adoption of cumbersome, uncomfortable apparatus on the head. However, these disadvantages are minor compared to the development of chronic sinusitis following packing of the antrum. Kazanjian (1927) and Gerrie (1938) maintain the fractured bones in their normal position by means of wires threaded either through drill holes or passed about a comminuted end of the involved bone. Traction is then exerted on these wires from a headcap. Direct wiring of the fractured bones has been reported several times with apparently satisfactory results.

SUMMARY

Twenty-six cases of fracture of the zygomatic bone and zygomatic arch have been studied. The outstanding signs and symptoms presented by these patients were swelling and depression of the face, trismus and pain in the jaw, ecchymosis, and anesthesia of the infraorbital region. The early literature on these fractures is reviewed and the treatment discussed. No new method of treatment is proposed. Treatment by one of the indirect methods usually suffices in early cases. In late cases additional support to the fractured bones may be necessary to prevent postoperative collapse. This may be accomplished by packing the maxillary sinus through a Caldwell-Luc approach, holding the bones

in the appropriate position, but external traction on the bone avoiding additional injury to the sinus appears preferable. Evidence is presented to show the increase in the incidence of these fractures since 1896

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Book Reviews

Modern Surgical Techniques (3 volumes). By Max Thorek, M.D., Foreword by D. C. Balfour, M.D. Cloth. Pp. 2,045, with 2,175 illustrations. Philadelphia, 1938, J. B. Lippincott Company. $33.

The author writes in his preface that these volumes are "intended particularly for students, for general surgeons and for those general practitioners who are occasionally called upon to perform emergency operations." One need not read far into the first volume to find the author describing the technique of removal of brain tumors and other highly departmentalized technical procedures.

The author obviously has not followed the task which he set himself to do. He has tried to embrace the entire field of operative procedures; a great ambition, but one that is neither possible nor laudable. The one-man text on surgery no longer fills a useful place in surgical literature, other than as it depicts in part the author's capacity to satisfy his own vain ambition to encompass the entire field of surgery or as it reflects, on the other hand, his ability to judge of the merit of other men's work. As Balfour states in the foreword, experience is a most significant factor in surgery; so important is it that this reviewer believes that the time cannot be far distant when bookmakers will realize that not many works by a single author, essaying to discuss all of operative surgery in an enlightened manner, are worth publishing.

To be sure, there may be found in these volumes much to commend them. The illustrations, in the main, are very good and in those departments of surgical knowledge where the author writes from his own experience, the text reaches its greatest heights. The author obviously has given much studied effort to the best known works of authors, but he has failed to document his text adequately with literature citations.

The obligation of authors and surgical bookmakers to their readers and the science and art of surgery is great. When authors and publishers are agreed that not more, but better, texts will enhance the art and science which they profess, only then will the writing of texts advance surgery. Surgical knowledge is also best disseminated in the various departments by those who have had personal experience with the therapeutic agencies which they describe.

Les Hermaphrodites et la Chirurgie. By L. Ombrédanne. Paper, pp. 322, with 113 illustrations. Paris, 1939, Masson et Cie. 85 fr.

Ombrédanne here presents his own views of hermaphroditism and pseudohermaphroditism. These differ sharply from those currently held and are ably defended. He believes that what might be called the "practical sex" of the sexually anomalous individual should be determined, not only by the microscopic character of the gonads, but also by the form of the external genitals, by the secondary sex characters, and especially by the inclinations (libido) of the individual. The secondary sex characters coincide more often with the external genitals than with the gonads. He advocates abandonment of the classical terminology and of existing classifications of hermaphroditism and pseudohermaphroditism, proposing instead to employ, after

Pozzi, the terms androgynoid and gynandroid. Androgynoid means that the gonads have the gross and sometimes the microscopic appearance of testes, often with feminine secondary sex characters and with variable sexual performance. The gynandroid individual has gonads with the characteristics of ovaries, and often has masculine secondary sex characters and a variable sexual performance.

He believes that biopsy of the ovotestis in the hermaphrodite may be misleading, since testicular tissue may be surrounded by ovarian substance, or the two elements may lie side by side, or one above the other. Thus biopsy may recover only ovarian or testicular tissue when both are present.

He reviews the various theories which attribute these anomalies to endocrine disturbance but concludes that they are due to some defect inherent in the chromosomes.

While most cases are recognizable on physical examination, many are discovered at abdominal operations, such as appendectomy, when uterus, tubes, and ovaries are found in what appeared to be a male with undescended testes; or when a testis is discovered in an inguinal hernia in a female.

Since it is often impossible to determine the sexual tendencies until after puberty, Ombrédanne is opposed to such operations as amputation of the penis or removal of the gonads until after the individual's own wishes can be ascertained. Therefore, in the otherwise apparently female child with a penis, he buries the intact organ beneath a fold of skin where its size will not embarrass the growing "girl." If masculine tendencies appear after puberty, it can be brought out and a penile urethra reconstructed; if feminine tendencies appear, it can be amputated. He also describes a plastic operation for enlarging a rudimentary vagina.

Included with his reports of twenty-two personal cases are many excellent photographs. The diagrams of operations are poor. There are brief discussions of hermaphroditism in mythology, art, and literature, as well as of its etiology, embryology, anatomy, and physiology.

This is an excellent and stimulating book for anyone interested in the subject and makes a good companion to Neugebauer's and Young's works.

Cardiovascular-Renal Disease: A Clinico-Pathologic Correlation Study Emphasizing the Importance of Ophthalmoscopy. By Lawrence W. Smith, Edward Weiss, Walter I. Lollie, Frank W. Konzelmann, and Edwin S. Gault. D. Appleton-Century Company, New York. 1940. Pp. 227, with 76 illustrations. Cloth. Price $4.50.

Five collaborators from Temple University have written a small monograph on cardiovascular-renal disease with emphasis upon the ophthalmoscopic changes. The reviewer admits a prejudice against the title *Cardiovascular-Renal Disease*, since the authors include such unrelated conditions as the hypertensive kidney, all forms of glomerulonephritis, the mercuric chloride kidney, the amyloid kidney, pyelonephritis when associated with hypertension and eclampsia. One wonders why polycystic renal disease and hydronephrosis were not included since they sometimes cause hypertension. Notwithstanding the multiple nature of the cardiovascular-renal group, the authors treat it as one entity at least in their statistical discussions.

They have a naïve trust in the reliability of vital statistics from insurance companies and agree that about 50 per cent of all deaths in persons over 50 years old are due to cardiovascular-renal disease. The report from the Metropolitan Life Insurance Company, from which the statistics are apparently taken, includes as "cardiovascular-renal" a hodgepodge of diseases, among which are chronic valvular heart disease, diseases of the arteries, and chronic myocarditis. The authors do not

mention valvular disease in their discussion of the cardiovascular-renal group, but they include it in their statistics. Nothing but confusion can result from the treatment of such a miscellaneous group as an entity.

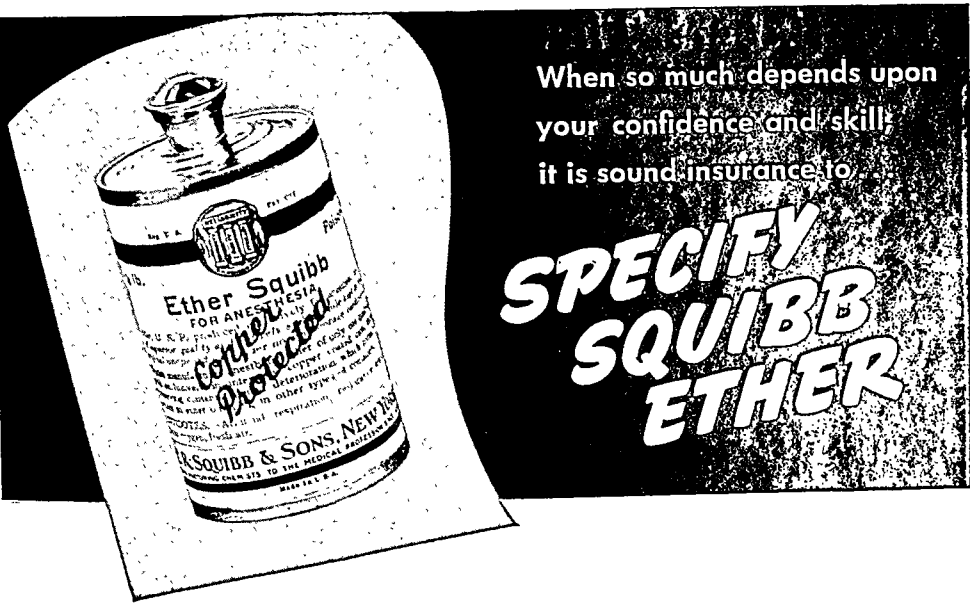
Such uncritical statements occur as "physicians as a class seem peculiarly susceptible to" heart disease (page 9); "after age 45 the death rate from 'cardiovascular-renal disease' is four times that from cancer" (page 44).

The different forms of essential hypertension, viz., benign, severe benign, and malignant, are well illustrated with clinical histories and pathologic reports. The authors seem to limit malignant hypertension to those cases that show a necrotizing arteriolitis; they do not mention proliferative intimal thickening which is much more frequent in malignant hypertension. They seem to confuse intimal and medial changes in arterioles; a connective tissue stain would show their medial disease to be intimal in most instances.

The illustrations of the eyegrounds are good, but in microscopic sections choroidal vessels are usually shown.

The writers accept without question the view that pyelonephritis and eclampsia are common causes of hypertension. Their case of "malignant nephrosclerosis following severe pyelonephritis" (page 168) might more readily be interpreted as an accidental association of the two diseases.

The commendable features of the monograph are the opthalmoscopic studies, the discussion of pathogenesis and the sane therapeutic considerations. It does not, however, contain anything original.



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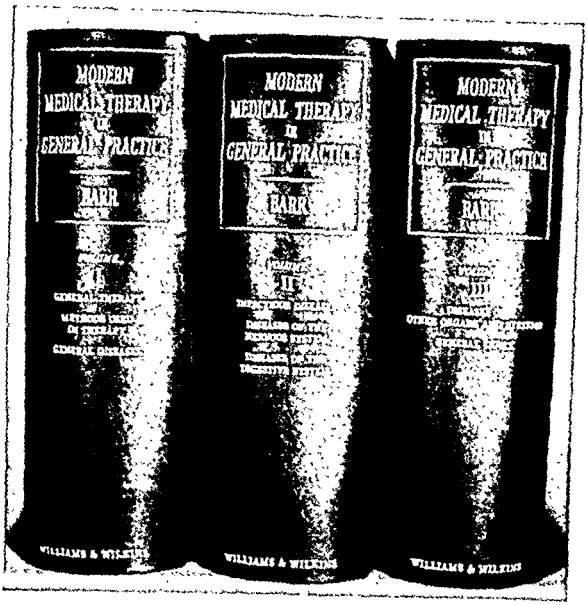
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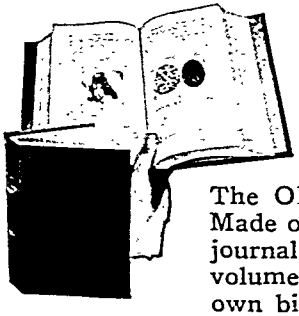
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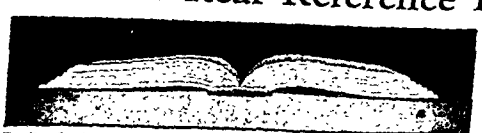
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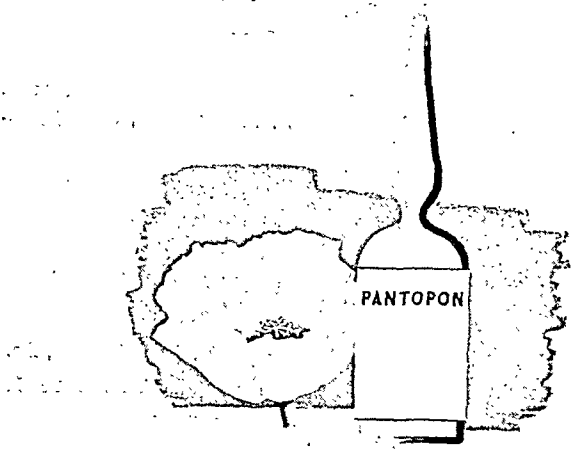
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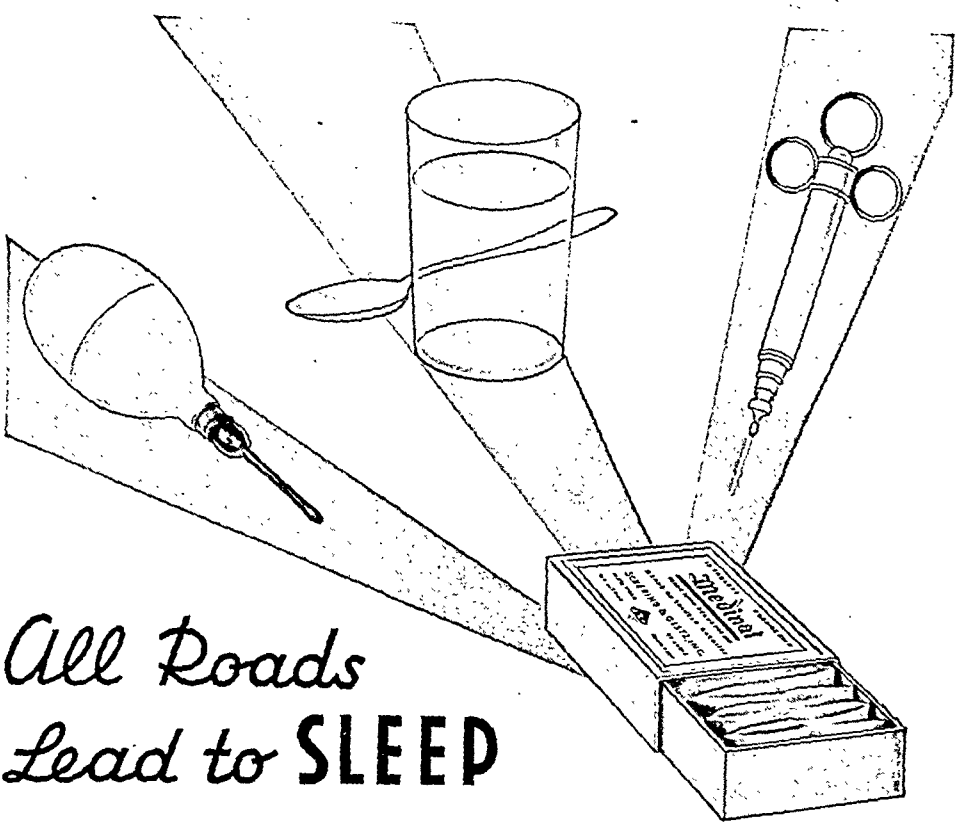
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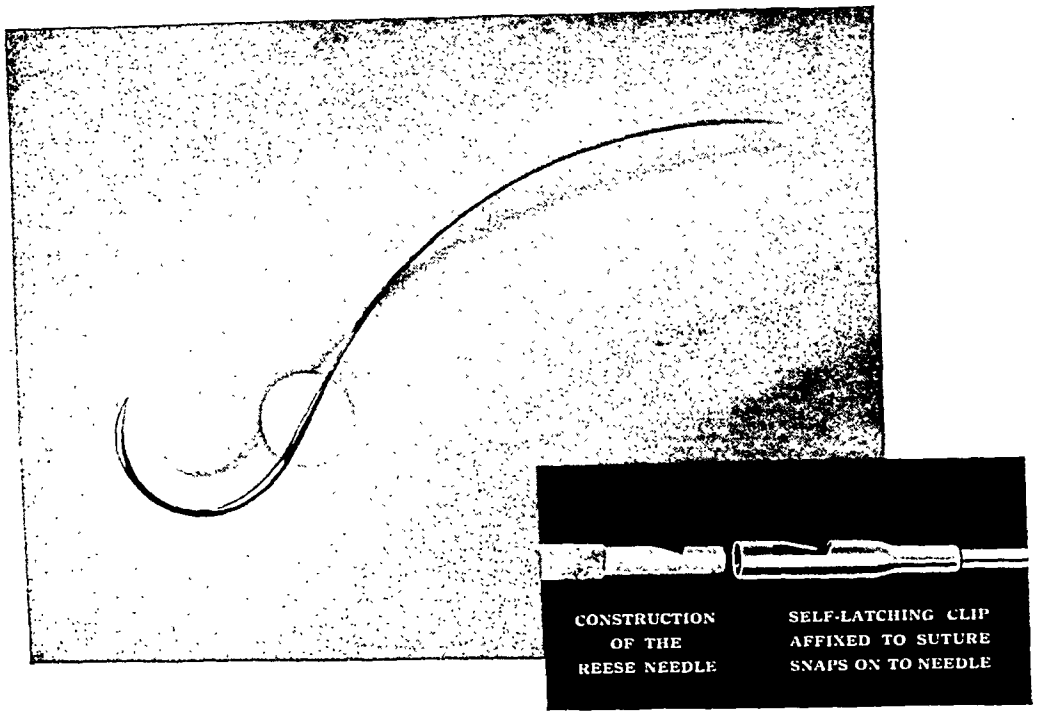
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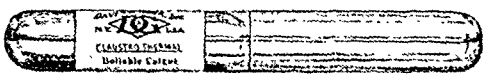
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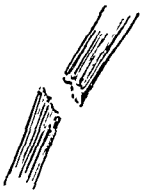


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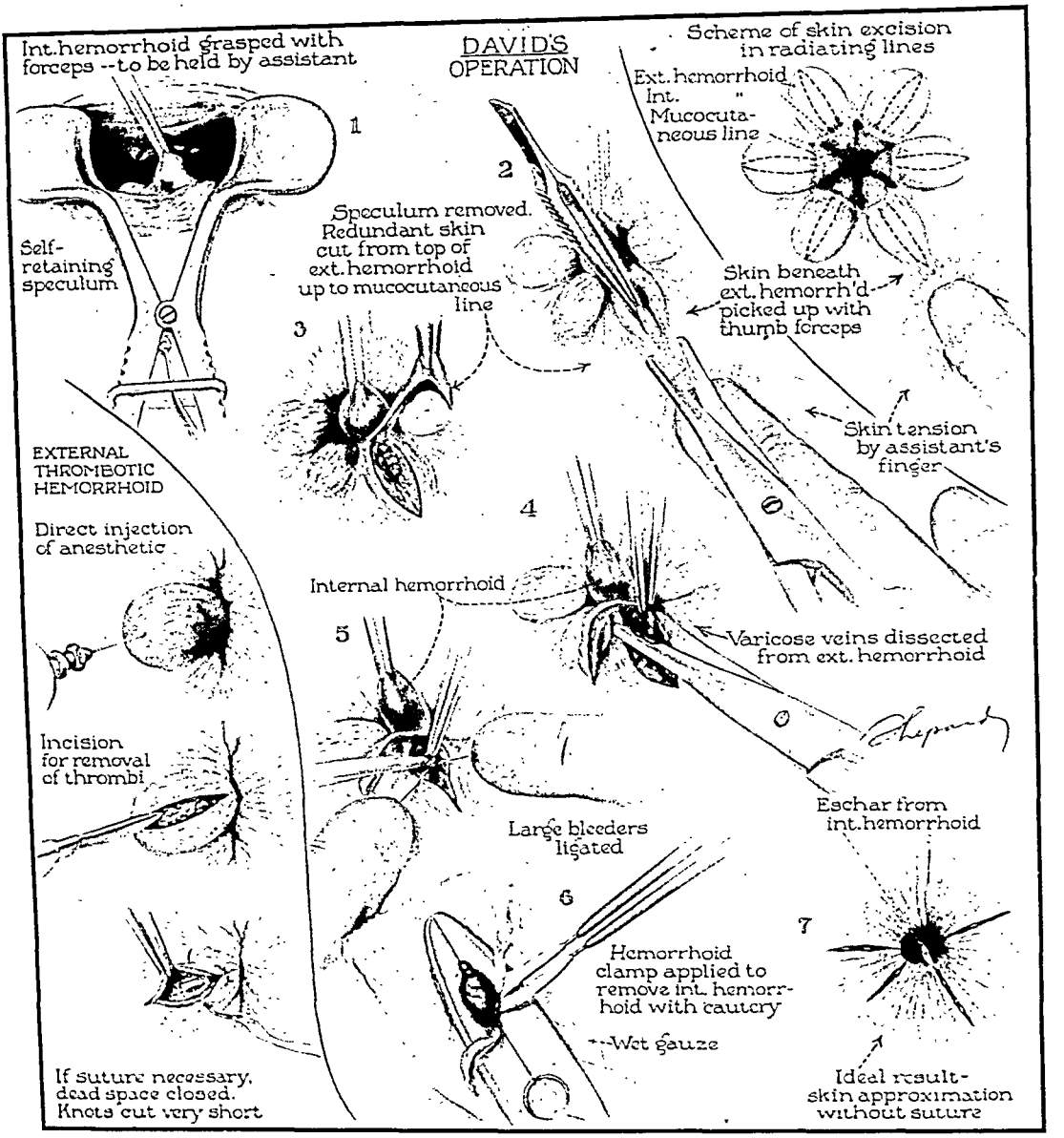
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Original Communications

A HISTOLOGIC STUDY OF THE THYROID OF EXOPHTHALMIC GOITER AT INTERVALS DURING THE ADMINISTRATION OF IODINE

WILLIAM D. WILSON, M.D.,* AND CHARLES W. MAYO, M.D.,
ROCHESTER, MINNESOTA
(From the Mayo Foundation and the Division of Surgery, the Mayo Clinic)

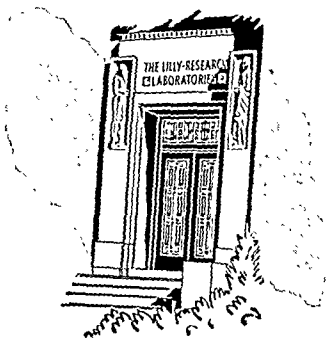
THIS study is based upon the pathologic observations on thyroid tissue removed at operation from 110 patients suffering from exophthalmic goiter who were treated at the Mayo Clinic. These patients had been treated by stage lobectomy, the interval between stages varying from twelve to three hundred days. Of these patients 100 had been given compound solution of iodine (Lugol's solution) previous to the first stage and during the interval between stages. In ten cases, used as controls, iodine had not been given either previous to the first stage or in the interval between operations.

Separate sections were made for each stage, the identity and date being placed on the label which was then covered so that only the identity was visible. Upon microscopic study the sections were designated as A and B with no knowledge as to which stage was represented. Microscopic observations in the entire series were recorded before this was known and without knowledge of the clinical data. By this method all possible bias was eliminated.

Sections of tissue were selected for microscopic study from the center of each lobe because Giordano and Caylor have shown that ligation of the thyroid vessels causes changes in the poles of the gland somewhat comparable to those produced by the administration of iodine.

The sections were studied microscopically as regards the accepted criteria[2, 3, 14, 15] of the constituents of the hypertrophic parenchymatous thyroid. These changes are well known but will be briefly described here. The normal cuboidal lining epithelium becomes columnar. The

*Fellow in Surgery, the Mayo Foundation. Now residing in Marietta, Ga.
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RESULTS

Hertzler studied material from stage thyroidectomies and stated that in the second stage the material is similar to that removed at the first operation as regards its cellular structure. He felt that the changes present were found in the colloid, which he found to stain more deeply and to fill out the acini more completely. Cattell[4] also studied the material from forty-one patients on whom stage thyroidectomies were done. Of these, thirteen had had compound solution of iodine before both stages. In nine cases of this group a decrease in activity, or involution, was noted; one case showed an increase in activity and in three cases there was no demonstrable change in the histologic picture.

In the series reported here of 100 cases in which the patients were treated with Lugol's solution, no change in activity was noted in 57 cases; in 25 cases there was an increase in activity in the second stage over the first, and in the remaining 18 cases a decrease in the histologic evidence of activity was noted. In the "no change" group the average interval between stages was 93 days; the average number of days of administration of compound solution of iodine, 139.1. In those cases in which an increase in activity was noted in the second stage, the average interval between stages was 90.5 days; the average number of days of administration of iodine, 147.4. In those showing a decrease in activity in the second stage the average interval was 108.6 days; the average number of days of administration of iodine was 163.3. In the controls no change was noted in 3 cases, an increase in activity in 2 cases, and a decrease in 5 cases.

Table I relates the change in activity of the material from the two stages to the total days of iodine administration. The majority of cases in which activity was increased in the second stage over that of the first fall within the shorter intervals of iodine administration, while in those in which a decreased activity was noted in the second stage the interval of iodine administration is longer as an average.

TABLE I

RELATION OF CHANGE IN ACTIVITY TO TOTAL DAYS OF IODINE ADMINISTRATION

	TOTAL DAYS OF IODINE ADMINISTRATION						
	0-49	50-99	100-174	175-249	250-324	325-399	400+
Increased activity	4	4	10	5	2	0	0
Same activity	4	19	22	5	4	2	1
Decreased activity	2	2	6	5	2	0	1
Activity grading	+0.20	+0.08	+0.10	0	0	0	-0.50

Table II, giving a similar comparison of change in activity with the days of administration of iodine between stages, shows a similar trend. In other words, it seems that in this series in cases in which a change was noted more cases showed histologic evidence of decreased activity in the second stage when the interval of iodine administration was prolonged than when it was short.

acinar lining, smooth in the normal thyroid, becomes broken by the appearance of papillary infoldings, dependent in their formation upon the hypertrophy of the lining cells. Colloid becomes reduced in quantity and is thin and fragmented in appearance. In addition to these Warthin described a fourth change, the collection of lymphocytes within the gland. Upon administration of Lugol's solution, as was shown by Reinhoff, the above abnormal characteristics tend to approach normal.

In this study the terms increased and decreased activity have been chosen to apply to the changes in the histologic picture undergone when the hypertrophic or involutional phenomena take place. It would seem that these changes could be thought of as evidence of increased activity within the gland as opposed to evidence of decreased activity referring to involution. It is true that these changes occur in experimental animals[10] upon removal of a portion of the normal gland, but here again this seems to indicate increased activity in the remaining portion. The use of this term precludes the use of such expressions as "increased parenchymatous hypertrophy" while it designates this change. The amount and quality of colloid present were considered only secondarily because of the technical difficulty of retaining all the colloid through the processes of cutting and staining.

Regenerative hyperplasia,[1] thyroiditis, fibrosis, and vascularity were also noted as was the presence or absence of germ centers. These characteristics were graded individually on the basis of one to four, the sections of the two stages from each patient being compared directly. Thus, if the material from the first stage should show higher epithelium, more papillary infoldings, and less colloid than that of the second stage, the first is considered "more active" than the second and vice versa.

The material was compared in this manner as regards the total days of administration of iodine, the number of days of iodine between the two stages, the seasonal variation, and in association with the basal metabolic rate of the patient. The findings were graphed in the following manner: each gland which showed evidence of increased activity in the second stage was graded as +1; each gland in which a decreased activity was noted in the second stage was graded as −1; and those where no demonstrable change was found were graded as 0. The "activity gradings" are the average of the sum of each column in the various tables.

In the material used previous operations had been performed as follows: ligation of vessels, 17; hot water injections, 14; thyroidectomy, 10; ligation and hot water injections, 8; and none, 51. In the control series 7 cases had had previous vessel ligation, 1 had had both vessel ligation and hot water injection, and in 2 cases no operation had been done.

by comparing the average change in basal metabolic rate in this small group to the number of days elapsing between the readings. It will be noted that the greatest average change in basal metabolic rate was obtained in the group in which the smallest number of days elapsed between readings and also the smallest number of days of iodine administration.

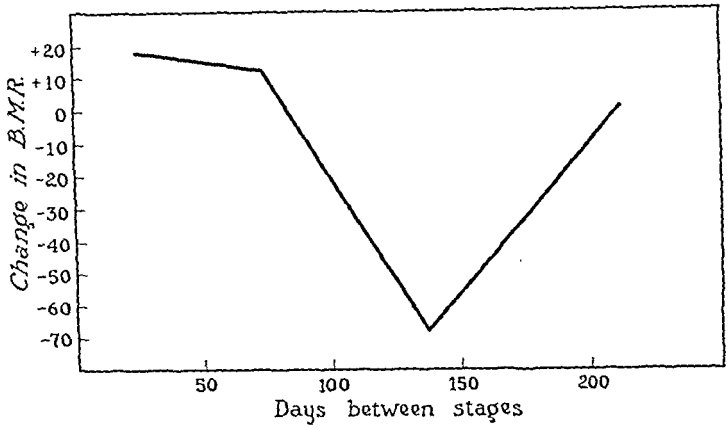


Fig. 2.—Average change in basal metabolic rate from soon after the first stage of thyroid lobectomy to before the second stage, in relation to length of time between stages.

Table III is based upon the ratio of the basal metabolic rate before each operation to the weight of removable gland in grams. Thus, in the first stage the basal metabolic rate is divided by the total weight of gland removed in both stages and in the second stage by the weight removed at that operation. It would seem that a high ratio might be interpreted as meaning more intense glandular activity. A greater decrease in the ratio of the second stage from that of the first stage might indicate a greater decrease in "activity" of the gland. As is shown in Table III, the decrease in the ratio was greater in the group classified on a histologic basis as showing a decrease in activity than in the group showing no histologic change and still greater than in the group showing histologic evidence of increased activity. These findings may help to confirm the criteria and method used in this study. By these criteria there is no evidence to indicate an increase

TABLE III

RATIO OF BASAL METABOLIC RATE BEFORE EACH STAGE OF LOBECTOMY TO WEIGHT OF REMOVABLE GLAND IN GRAMS IN RELATION TO THE CLASSIFICATION OF CHANGE OF ACTIVITY OF THE THYROID ON A HISTOLOGIC BASIS

	RATIO 1ST STAGE	RATIO 2ND STAGE	DECREASE
Increase group	2.73	1.97	0.76
No change group	2.98	1.69	1.29
Decrease group	3.16	1.58	1.58

TABLE II

RELATION OF CHANGE IN ACTIVITY TO DAYS OF IODINE BETWEEN STAGES OF LOBECTOMY

	DAYS OF IODINE				
	0-49	50-99	100-149	150-199	200-249
Increased activity	7	8	9	0	1
Same activity	18	22	9	4	4
Decreased activity	4	6	4	2	2
Activity grading	+0.10	+0.05	+0.22	-0.33	-0.14

Upon comparing the grade of activity of the second stage on the basis of one to four without regard for the first stage Fig. 1 was obtained. No definite tendency to increased activity was noted after prolonged intervals of iodine administration. A study of the "activity grading" based upon the number of months of the disease gave no significant findings and is not included here.

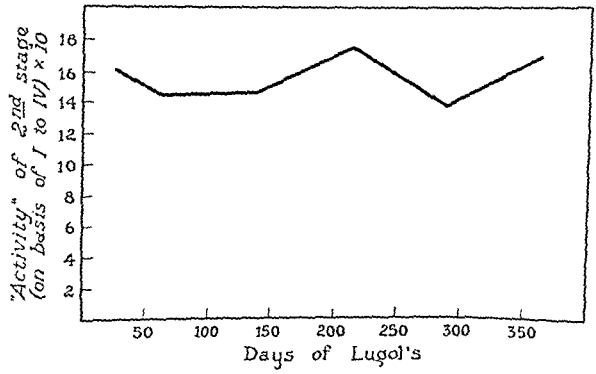


Fig. 1.—Average activity of thyroid tissue at the second stage of lobectomy in relation to the length of time during which the patient had received Lugol's solution.

Consideration of basal metabolic rates shows an average drop in the basal rate of 11.1 degrees in the group in which no change was noted; a drop of 15.1 degrees in the group showing an increased activity in the second stage; a drop of 17.7 degrees in the "decrease" group. Those were the final basal rates taken before each stage.

In 27 cases basal metabolic rates were taken soon after the first stage was done. These were compared with the basal metabolic rates before the second stage after an interval of administration of compound solution of iodine averaging 181.1 days. The average basal rate after the first stage was +34.7 per cent and that before the second stage was +33.3 per cent, a drop of 1.4 per cent or practically no change. The average interval between the stages in this small group was 115.8 days. Obviously an identical amount of thyroid tissue was present in the patient for both of these readings. Fig. 2 was obtained

TABLE V

RELATION OF CHANGE IN ACTIVITY TO MONTH OF SECOND STAGE OF LOBECTOMY

	MONTH OF SECOND STAGE OF OPERATION											
	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Increased activity	2	2	3	2	2	0	0	5	0	2	4	3
Same activity	7	2	7	2	5	8	2	5	4	3	4	8
Decreased activity	2	0	2	2	1	2	3	2	1	1	2	0
Activity grade	0	+0.50	+0.08	0	+0.12	-0.20	-0.60	+0.25	-0.20	+0.16	+0.20	+0.27
Average days iodine between stages	89.8	69.7	86.0	69.8	114.8	109.7	84.0	58.6	83.8	107.8	88.2	67.3
Average months disease	22.2	62.2	28.9	31.3	31.0	29.0	59.4	40.6	7.4	48.8	20.3	22.1

in thyroid activity after varying periods of medication with Lugol's solutions. The average weight of gland removed in the first stage was 77.5 gm.; in the second stage, 64.1 gm.

Interesting data were obtained upon studying the material as regards the season in which the second stage was done. These are shown in Table IV. There seems to be a tendency to increase in activity of the gland during cooler weather. This finds some confirmation in the work of Curtis, Kendall, and Cattell,[3] who found the iodine content of the human thyroid to be highest in the summer and lowest in the winter. The iodine content of the gland has been shown to vary directly as the amount of colloid present or inversely as the amount of "activity" present.[11] Also Loeb found the average hypertrophy to be less marked in the summer months than in experiments carried out during the winter on guinea-pigs upon which previous partial thyroidectomy had been done. These findings were graphed to show the relation of the activity of the gland to the month of the second stage by the method used previously (Table V). Accompanying this table are the average days of iodine medication and the average months of duration of the disease for each period. As will be seen, these factors are eliminated as having bearing on the findings in Table V. Except for a discrepancy in the month of August, there seems to be shown by this method, also, an increased activity in the cooler months.

TABLE IV

RELATION OF CHANGE IN ACTIVITY TO SEASON OF SECOND STAGE OF LOBECTOMY

	2ND STAGE IN COOLER SEASON	2ND STAGE IN HOTTER SEASON	BOTH STAGES SAME SEASON
Increased activity	13	8	4
Same activity	23	23	11
Decreased activity	6	11	1
Controls:			
Increased activity	1	1	0
Same activity	0	1	2
Decreased activity	1	3	1

With regard to regenerative hyperplasia, we did not know when the study was begun whether this could be taken as a criterion of activity. Consequently, this was considered independently. It was found, however, that the amount of regenerative hyperplasia present varied in direct proportion to the increase or decrease in activity noted in all but six cases. Conversely, colloid when judged by amount and quality present, varied inversely as did the activity in all except nine cases. As was stated previously, colloid was not used as a criterion of activity because of possible loss in cutting and staining.

In a comparative study of thyroiditis, germinal centers were found in 15 cases. An increase in thyroiditis in the second stage over the first stage was found in 29 cases. In 66 cases there was no change

the majority of patients treated for long intervals by iodine in which a change was noted while there is some histologic evidence of increased activity in the second stage in the glands of most of those treated for shorter periods where a change was seen.

2. There seems to be histologic evidence of an increase in activity of the thyroid gland in exophthalmic goiter during the winter months.

3. The amount of colloid varies inversely as does the "activity" of the thyroid gland.

4. The amount of regenerative hyperplasia in the gland varies directly as does the "activity" of the thyroid gland.

5. That the histologic observations made in this study are valid is suggested by the computation and co-ordination of the ratio of basal metabolic rate to weight of thyroid substance removed.

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noted, and in 5 cases an apparent decrease was seen. The average number of days between stages and days of iodine medication were of no significance. In the controls no germ centers were found; and increased thyroiditis was noted in 3 cases, a decrease in 3 cases, and no change in 4 cases. No significant findings were made with regard to fibrosis.

COMMENT

There is considerable discussion in the literature as regards the duration of the effectiveness of iodine in the control of exophthalmic goiter. In general it is accepted that after a period of ten to fourteen days of so-called iodine remission there is an exacerbation of symptoms. Cattell,[4] however, has shown that the maximal iodine effect on the iodine content of the thyroid gland rarely occurs in less than one month and often not until after two months have passed. Plummer and Boothby also stated that maximal improvement usually occurs after iodine has been administered from eight to ten days but may be delayed two or even three weeks. Plummer[12] expressed the opinion that the response of patients with exopthalmic goiter to prolonged iodine medication appears to be determined more by what is happening to the disease spontaneously than by the iodine itself. He stated that he found no evidence that the effects of iodine were temporary. In the formulation of his two-product hypothesis of secretion of the thyroid gland he stated that iodine controls the "abnormal product" but does not control the complex caused by an excess of thyroxin. Thus, the alternation of exacerbations and remissions characteristic of the disease continues but on a smaller scale and with more marked remissions than would be seen without the control offered by iodine.

The observations in this study add nothing to settle the debate as to the time of maximal iodine control but seem to suggest that the histologic picture of exophthalmic goiter does not show evidence of increased activity after prolonged iodine administration in all cases. However, in the material where iodine was administered for shorter intervals of time (up to 150 to 200 days), it seems that there is histologic evidence of increased activity in the gland removed at the second stage operation over that removed at the first in the majority of cases studied here, where a definite change was noted.

SUMMARY AND CONCLUSIONS

One hundred cases in which exophthalmic goiter was treated by iodine and operated upon in stages have been studied histologically with a control group of ten cases in which Lugol's solution was not given. The following conclusions were drawn:

1. It seems that in this series there is evidence of a tendency toward decreased activity or histologic involution in the thyroid glands of

ish suede leather with a crenated outer margin around which there is a raised purplish zone about 0.5 to 1 cm. in width. This stands up above the level of the surrounding skin which is the seat of a brilliant erythema for a distance of several centimeters outside of the raised purple zone. Hyperpyrexia is not commonly observed, but the lesion is intensely painful and tender. The severity of this symptom, coupled with the usual inability of the surgeon to stop the infection, results in marked character changes. Individuals whose personalities have always been jovial and happy become very morose, uncooperative, and depressed. This infection is rebellious to all kinds of ordinary wound treatment. It is entirely uninfluenced by multiple incisions and drainages, hot or cold wet dressings, or the application of the ordinary disinfectant agents. Likewise, Alpine sunlamp or other forms of radiant energy are without benefit.

If an incision is made in the erythematous or reddened zone of advance, it is here that the microaerophilic nonhemolytic streptococcus will be found in pure culture, and associated with it the hemolytic staphylococcus will be found in the suede leather or zone of gangrene. It is well to excise blocks of tissue for cultural procedures and for a further study of the bacteria in the field. Meleney is convinced that the treatment of this condition demands radical excision of the whole process outside of the zone of erythema and that the application of zinc peroxide immediately after the excision will greatly aid in the control of the infection and prevent a recurrence. Only the "medicinal grade" should be used. The scalpel or radio knife may be used and *any healthy granulations or normal epithelium may be left.* The zinc peroxide should be sterilized in small quantities, 5 to 15 gm. at 140° C., dry heat, for four hours. It is to be applied as follows: The dry powder is suspended in approximately equal quantities of sterile distilled water so that it has the consistency of 40 per cent cream. This may be mixed with an asepto syringe and must be applied to every part of the wound surface. It is essential that the entire area be covered with the preparation. When this has been done, a double layer of fine mesh gauze soaked in the suspension of zinc peroxide should be placed over the surface and this, in turn, covered with gauze compresses or cotton wet with sterile distilled water. The whole dressing then should be sealed with several layers of vaseline gauze to prevent evaporation. After twenty-four hours, the dressings should be changed and the wound irrigated with saline solution in order to remove the exudate and old zinc peroxide. It is then reapplied as before. In about ten or fourteen days, when the whole area is covered by healthy granulations and new skin is growing in from all margins, grafts may be applied. Pinch grafts will be more satisfactory than Thiersch grafts in most cases. Complete healing may be expected in from three to four weeks after the time of excision. The recommendation is made that the skin and *subcutaneous tissue should* be left

PROGRESSIVE POSTOPERATIVE GANGRENE OF THE ABDOMINAL WALL

WITH A CASE REPORT

HENRY J. VIER, M.D., WHITE PLAINS, N. Y.

PROGRESSIVE postoperative gangrene of the abdominal wall is a pathologic entity originally described by Cullen, and more recently in fuller detail by Meleney, in a number of reports. So few have been reported that it seems worth while to call it again to the attention of the profession. In fact, this condition is so rare that it is usually not observed more than once or twice in the experience of the average surgeon; but, when it does occur, it is so devastating to the patient and distressing to the surgeon that one is impressed with the importance of its early diagnosis and proper treatment.

One of the most remarkable cases, recently reported by Stewart-Wallace in the *British Journal of Surgery,* occurred in the London Hospital in 1935; following a thoracotomy and drainage of an empyema, a slowly progressive gangrenous infection of the skin and subcutaneous tissues developed. This gradually spread in spite of all therapeutic measures until after eight months it stretched from the occiput to the iliac crest behind, extended anteriorly to involve the whole abdominal surface, and finally caused the death of the patient. Several surgeons, physicians, and others at the London Hospital saw the case, but none of them could remember having met this remarkable condition before. Stewart-Wallace states that only two such cases have been described in English journals. One or more cases have also been reported in Japan, Sweden, Germany, Italy, and Australia. A review of the literature today reveals fewer than forty authenticated case reports of this condition, most of them from this country. It usually develops in an operative wound following the drainage of a peritoneal abscess, a lung abscess, or a putrid empyema. It usually begins during the second postoperative week as a painful area around a retention suture. It is often described as having a carbuncular appearance with pain, redness and swelling, and early necrosis of the skin. The surgeon may remove the offending suture at this stage, but the infection does not subside. He may then attempt an incision or a conservative excision of the gangrenous tissue, but this does not bring the infection under control. The deep drainage tract may heal, but the superficial lesion continues to advance; an ulcer forms in the center and around it the circle of gangrenous skin gradually enlarges, the central margin melts away, and the periphery gradually becomes more sharply outlined. The gangrenous margin takes on the appearance of grayish or brown-

Received for publication, August 2, 1939.

SURGERY
VOL. 7, NO. 3, MARCH, 1940

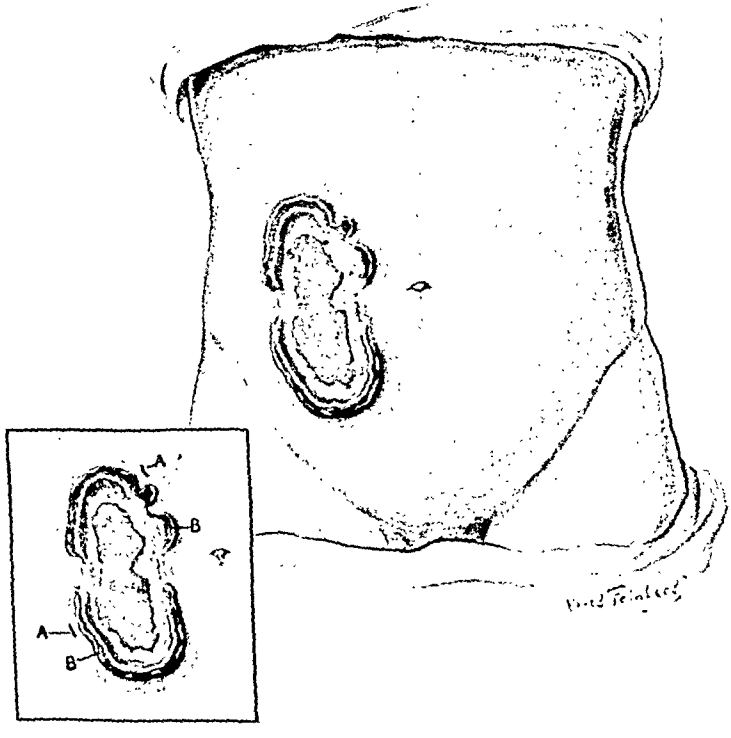


Plate I.—Illustrating lesion of progressive postoperative gangrene. *A*, Zone of advance; location of microaerophilic, nonhemolytic streptococcus; *B*, zone of necrosis; location of the hemolytic staphylococcus.

widely opened and the wound packed after drainage of an intra-abdominal infection, as peritoneal contamination by intestinal streptococci and staphylococci occurs commonly.

CASE REPORT

Patient, Mr. G. L., an adult white male, aged 64 years, with past history irrelevant except for a resection of the sigmoid at another hospital eleven years ago for carcinoma. It was done in one stage, an end-to-end anastomosis being performed. This was complicated by an infection with a resulting fecal fistula which persisted for several months. There has never been any evidence of recurrence.

The present illness began with generalized abdominal pain about forty-eight hours before admission. This was accompanied by nausea and vomiting. Shortly after the onset of pain, the patient took a large dose of citrate of magnesia. This was followed by a violent purge and a temporary subsidence of the pain. After an interval of several hours, the pain returned over all the abdomen. This pain steadily increased until he was admitted to St. Agnes Hospital at 11:40 A.M. on May 8, 1938.

Examination revealed an elderly-appearing male with a temperature of 101; pulse, 90; respirations, 24; and blood pressure, 108/60. Facies were quite anxious and mucous membranes showed evidence of slight dehydration. Head and neck were essentially negative. Chest was negative. Heart sounds were of poor quality, regular, no murmurs. Inspection of the abdomen revealed a lower left rectus scar with considerable widening at its lower angle, obviously the site of the former fecal fistula. There was no evidence of hernia. Generalized tenderness and marked rigidity of the entire lower abdomen were found, together with severe rebound tenderness. The extremities were negative. The urinalysis was essentially negative. The blood count showed a marked phagocytosis with an equally marked shift to the left. A diagnosis of acute suppurative appendicitis was made. He was taken to the operating room at 12:30 P.M. and was given a general anesthetic of gas-oxygen-ether sequence.

At operation, a low, right, paramedian incision was made. Upon opening the peritoneum, there was evidence of a large amount of foul-smelling, brownish pus in the peritoneal cavity. Large and small gut were considerably distended. The serosa was markedly injected and covered here and there with plastic lymph. Two or three fecaliths were found in the gutter in the lower right quadrant. The appendix was gangrenous for its entire length. A large opening was found in the distal third through which was extruding a large fecalith; dense adhesions were found just to the left of the midline, obviously secondary to the intestinal resection for carcinoma of the descending colon done eleven years ago. A smear of the peritoneal fluid showed gram-positive and gram-negative bacilli and gram-positive cocci resembling streptococci. The culture showed *B. coli* and *B. proteus;* the gram-positive bacilli and streptococci did not grow out on aerobic cultivation. The significance of this was not appreciated at the time. Pus was removed with suction and the peritoneal cavity flushed with saline solution continuously removed by suction. The appendix was removed. A large, self-retaining catheter was inserted into the cecum and held in position with three purse-string sutures of chromic catgut. This was brought out through the lower angle of the wound. All small gut was then excluded from the pelvis and a coffer dam of rubber tissue, containing multiple gauze wicks, was inserted and was brought out alongside the cecostomy tube. The abdomen was then closed as follows: continuous plain catgut suture for the peritoneum and posterior sheath, interrupted chromic sutures for the anterior sheath, three silkworm gut retention sutures which included the anterior sheath for the skin with clips in between. A Wangensteen tube was inserted through the nostril. The patient's immediate postoperative condition was apparently satisfactory.

SURGERY
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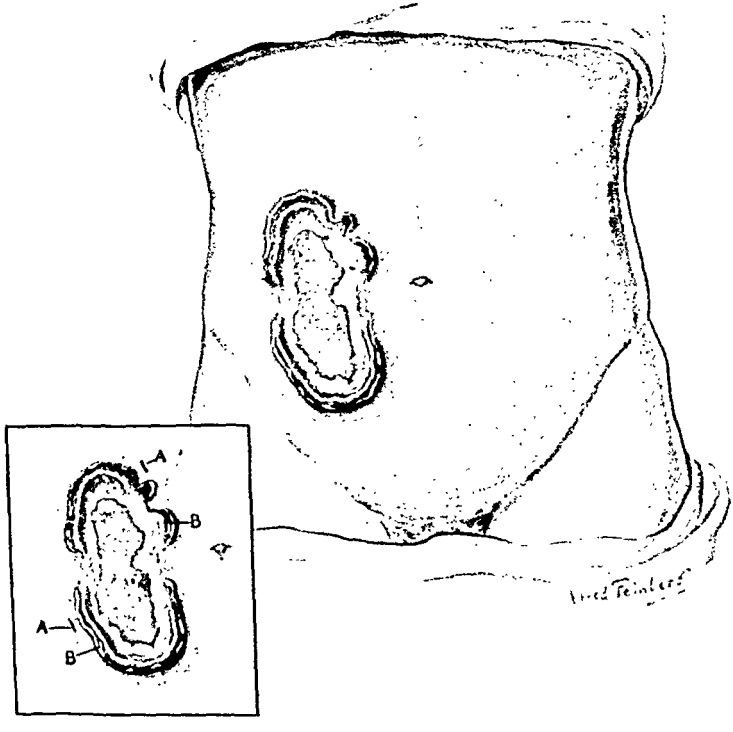


Plate 1.—Illustrating lesion of progressive postoperative gangrene. *A*, Zone of advance; location of microaerophilic, nonhemolytic streptococcus; *B*, zone of necrosis; location of the hemolytic staphylococcus.

On May 10, two days postoperatively, the patient reacted quite well. He had experienced no nausea or vomiting and had but a moderate amount of postoperative pain. A transfusion of 500 c.c. of blood was given by the direct method. There was no exceptional temperature elevation postoperatively except for the second day when it reached 103° F. and then returned to normal for the remainder of his stay in the hospital. Several other transfusions were administered. There was considerable purulent drainage from the coffer dam, but the cecostomy tube functioned poorly. A moderate degree of abdominal distention was successfully combated with the Wangensteen tube. About the eighth day the drainage became dark brown in character. At the same time, at the upper angle of the wound, considerable redness was noted, especially around the retention sutures. On May 17 the patient showed less distention. He had two bowel evacuations and expelled flatus freely but there was marked anorexia. The coffer dam and the cecostomy tube were removed on the tenth day and the retention sutures a day later. His blood chemistry at this time was normal. His postoperative course was thereafter uneventful. Patient was allowed out of bed on the nineteenth day. His appetite was improved. There was very little drainage and the fistulous tract to the cecum had apparently closed promptly upon removal of the tube. Some redness persisted, however, in the skin about the site of the retention sutures. The patient was discharged on the twenty-sixth day feeling considerably stronger. The wound drainage was minimal. Three days after his return home the drainage began to increase. The lower angle of the wound showed an elevated area of the skin with marked redness and apparent gangrene of the epithelial edge. There was considerable pain in the involved area and exquisite tenderness. On the following day there was practically no evidence of any response to wet dressing which had been applied. On the next day it was very much worse and patient was readmitted to the hospital. In the next few days the infection spread with considerably rapidity. The greatest activity was at the site of the lowest retention suture just above the drain. There was considerable elevation of the involved skin and within the next few days it became frankly gangrenous, gradually taking on a suede leather color and a zone of redness extended outward for approximately 2 or 3 cm., then paled into adjoining healthy skin.

By a strange coincidence, a few months before this time, a small surgical group, of which I am a member, spent a day at the Presbyterian Hospital visiting the surgical department. Models of various types of chronic ulcerations were demonstrated in the laboratory of Dr. Frank Meleney, and among them was a case of progressive bacterial synergistic gangrene. It was obvious that my case fell into this category. The patient was therefore taken to the operating room and given a general anesthetic. The lesion at that time appeared as illustrated in Plate I. The ulcerated area was approximately 8 cm. in diameter and had an irregular outline. The gangrenous zone was interrupted in several places. The raised purplish zone indicated the area where the gangrenous process was slowly spreading. The zone of erythema initiated the process. The entire infected area was excised down to fascia which was apparently not involved. The exposed area was then covered with a zinc peroxide (DuPont) dressing as described above. The culture of the gangrenous area showed *B. proteus* and hemolytic staphylococci. Anaerobic culture of the edges of the zone of erythema outside of the gangrenous area showed nonhemolytic streptococci which subsequent transplants proved to be not strictly anaerobic but microaerophilic. Laboratory reports submitted on the excised specimens showed a widespread suppuration with destruction of skin and subcutaneous tissues and little effort at repair. The pathologic diagnosis was gangrene of the abdominal wall.

Immediately following the operation, the patient observed a very gratifying relief from the extreme pain and tenderness present in the lesion. He was, however, mentally depressed and it was difficult to secure his cooperation. He ran a spiked fever which could not be explained by the benign appearance of the wound. Daily

dressings were then applied with zinc peroxide and the wound continued to improve. Drainage decreased and the granulations began to grow actively.

On the thirteenth postoperative day the zinc peroxide treatment was stopped and I attempted to approximate the upper wound edges with adhesive plaster. This was a mistake, for another small area of gangrene about 2 by 3 cm. in diameter promptly developed in the upper part of the wound. This area was excised on the following day under gas-oxygen anesthesia. Zinc peroxide was continued and the wound immediately lost all signs of inflammation. Nevertheless, the patient's appetite was extremely poor and his mental depression was very marked. The patient repeatedly refused his meals. Several transfusions were given during his postoperative course, but they did not seem to control the general debility. On the twenty-first day postoperatively, he complained of some deep pain in the lower left quadrant, and twelve hours later he passed about four ounces of blood per rectum together with several

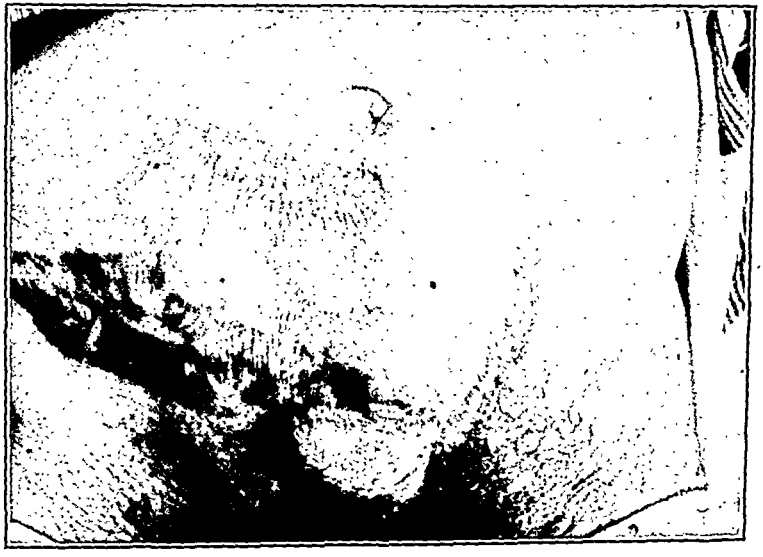


Fig. 1.—Healed lesion, several months postoperatively.

clots and a considerable amount of foul-smelling purulent material. It was evident that a deep-seated, intra-abdominal abscess had perforated into the colon and had evacuated itself in this way. His condition from then on showed marked improvement. His mental condition cleared and his appetite returned. The wound thereafter improved and there was no further evidence of spreading infection. A few islands of epithelium appeared spontaneously in the area of granulations which had not been removed. On the thirty-eighth day skin grafts were applied to the granulated area and the grafts took well, coalesced, and soon covered the wound. His convalescence from then on was uneventful. The patient was discharged from the hospital with two small remaining granulating areas having healthy edges. These wounds healed promptly following his return home, eighty days after the onset of his illness and fifty-four days after the development of gangrene.

DISCUSSION

This case unquestionably falls into the group of "progressive bacterial synergistic gangrene" described by Meleney and others. The lesion began in the operative wound following the drainage of a foul-

smelling peritonitis resulting from a gangrenous appendicitis. It developed later than most of the reported cases which raises the question of the source of the bacteria and the time in which the organisms first gained a foothold in the wound. They may have been present in the original peritoneal exudate or they may have entered the wound later when cecal contents leaked out around the cecostomy tube. In any event, either the pressure produced by the retention suture or by the coffer-dam drain probably played a role in the establishment of the infection and, once it became established, it spread with considerable rapidity.

Meleney has emphasized the factor of pressure in the development of the infection and has advised that no attempt be made to close the skin wound in any case in which foul-smelling abscesses are drained. After the infection had gained a foothold, the characteristic exquisite tenderness of the lesion and the change in the disposition of the patient were very striking. The cause for this has never been adequately explained. A noteworthy point during his illness was the rather marked toxicity after the excision of the lesion. This was probably due to the intra-abdominal abscess and not to the denuded area.

This deep infection probably explains why transfusions seemed to have but very slight influence toward increasing his resistance, until the deep abscess had evacuated itself through the bowel. The essential organism, a nonhemolytic microaerophilic streptococcus, which Meleney has found by anaerobic cultural methods in the zone of advance in all five of his cases, was also present in our case at the outer margin of the erythematous zone. We also recovered from the gangrenous area, associated with it, a hemolytic *Staphylococcus aureus*.

The synergistic experiments with these organisms which Meleney has performed on several occasions were not carried out. He has shown that, when these organisms are injected into laboratory animals (dogs, rabbits, guinea pigs) separately and in combinations (half doses of each), the pure culture usually failed to produce any inflammatory response while the combination almost always produced a profound purulent reaction in the tissue with gangrene of the overlying skin. While this lesion is not exactly like the human process in that it is not progressive, the experiments prove that these organisms in combination have a synergistic action which they lack when not combined.

Willard, of Tacoma, reported a similar case in 1935 and by careful laboratory work verified the results obtained by Meleney. Willard's case was likewise "characterized by slow but relentless progress, and by extreme sensitiveness of the area involved." Willard reported that with the organisms obtained from his case, four guinea pigs were given subcutaneous inoculations. The hemolytic streptococcus first obtained from the area of slough produced an abscess which cleared up. The nonhemolytic streptococcus from the zone of advance produced a small abscess. In contrast, the hemolytic staphylococcus and nonhemolytic

streptococcus injected together produced a large spreading ulcer of the skin and early death of the guinea pig. An understanding of the essential nature of this symbiotic infection simplifies proper treatment. It is obvious that wide excision is necessary to get control of the infection.

Whether scalpel or radio knife is used is of minor importance. Meleney prefers the knife because it means a minimal surface of injured tissue. Willard in his monograph stated: "It is probable that if radical excision is performed, a special dressing is of minor importance in controlling the infection." I cannot entirely subscribe to this, but I do believe that one need not be quite so radical in the excision where the zinc peroxide is used, as it was evident that the recurrence in my case was observed following radical excision and shortly after discontinuing the zinc peroxide. This unfortunate result emphasizes the folly of trying to approximate wound edges by means of adhesive. This naturally causes an infolding of the skin edges and the resultant angles produce minute pockets in which colonies of the causative germs may develop by producing or finding an anaerobic "soil."

DIFFERENTIAL DIAGNOSIS

This condition must not be confused with the undermining, ulcerating type of infection due to the microaerophilic hemolytic streptococcus. These burrowing tracts extend deeply and the undermining process proceeds as far as 4 to 5 cm. beneath the skin edges. This is not accompanied by gangrene and is caused by the microaerophilic hemolytic streptococcus, no symbiotic hemolytic staphylococcus being here associated.

A human bite nearly always contaminates the wound with a mixture of organisms. Many surgeons justly fear these infections because, ordinarily, gangrene frequently occurs here when there is a mixture of organisms which includes anaerobic nonhemolytic streptococci, fusiform bacilli, and spirochetes. It has been observed that, while spirochetes are never found alone in these infections, the worst one always reveal that spirochetes are present. With a fusospirochetal infection, we have a fulminating lesion spreading and penetrating deeply and soon involving deep tissues, including bone, with overwhelming destruction. It may occasionally be necessary to differentiate progressive postoperative from an amoebic gangrene. However, in this situation we have frequently a history of amoebic dysentery. Amoebae may be found in the stools or there probably will be found some other evidence of a deep amoebic lesion. Again, this condition responds promptly to emetin treatment. This lesion is also deeper, develops rapidly, and usually invades the muscle. Pressure on the margins produces glairy pus in which the amoeba may be found. Meleney's investigations of this condition have shown that this exudate "almost invariably yields,

besides the amoeba, a combination of organisms which may be contributing toward the severity of the infection."

A diagnosis of postoperative gangrene should be made within a week or ten days after the onset. A suspicion of the nature of the infection should be aroused by the clinical course. The diagnosis can only be made with certainty by adequate bacteriologic analyses of the flora of the wound. Early diagnosis is essential to early treatment which will save the patient an infinite amount of time, pain, and expense and will minimize the destruction of skin. Every hospital should have available apparatus and materials necessary to perform anaerobic cultures.

What the effect of the administration of sulfanilamide or sulfapyridine might have been in this situation, I do not know. They were not tried here.

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THE KELLER OPERATION—PARTIAL PHALANGECTOMY IN HALLUX VALGUS AND HALLUX RIGIDUS*

REPORT OF 55 OPERATIONS IN 32 CASES

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THE problem of hallux rigidus and hallux valgus is a very complex one. Results are very difficult to gauge accurately. In 1930, Timmer (quoted by Bentzon) described twenty-five different procedures for hallux valgus. Since then, modifications and new procedures have continued to reappear. This indicates that none is accepted as the operation of choice in all cases. The results in general are far less satisfactory than the ordinary attention paid to them would suggest. Haglund has divided hallux valgus cases into two groups: (1) patients treated by others, who then consulted him; and (2) patients he had treated, who then went to others.

Hamsa, reviewing 339 operations for hallux valgus at the University of Iowa clinic, concluded that only somewhat over one-half of the cases had "good" results with the Mayo operation (61 per cent). With the other operations, the "good" cases ranged from 57 down to 19 per cent. However, actual poor results were uncommon. The remainder were considered fair. At the international orthopedic meeting at Cologne in 1926, a combined report on the results of surgery in hallux valgus, based on hundreds of cases, was presented. Only 50 per cent were considered perfectly satisfactory results, the rest ranging from fair to poor. There are but a limited number of types of operations for these conditions, but each has been discovered and rediscovered several times. These are given with associated authors, as compiled by Hamsa and from other sources, in Table I.

The soft tissue operations, with or without exostectomy, have been used in mild cases, partly in a prophylactic way, and have a definite indication. They produce rapid convalescence with relief of symptoms if indications have been correct; that is, painful bursa over an exostosis, with little or no actual hallux valgus.

Osteotomies of the metatarsal neck, shaft, and base have corrected deformities of the most severe hallux valgus cases. The objection of prolonged convalescence and delayed return to work has prevented them from gaining wide adherence. The altered weight bearing in shortening or plantar flexing the first metatarsal shaft is the cause, in addition

*Presented before the Orthopedic Section, New York Academy of Medicine, New York City, March 17, 1939.
Received for publication, July 27, 1939.

TABLE I

1. Exostectomy	Schede
2. Exostectomy and capsuloplasty, soft tissue and tendon procedures	Silver, McBride, Porter, Roberts, Hiss, Payr, Stanley, Leuggenhagger and others
3. Resection of first metatarsal head	Hueter, Mayo, Perkins, Roth, Soresi, Lexer, Fowler, Ombredanne, Cleveland, Broca, Bentzon and co-workers
4. Resection of proximal phalanx plus first metatarsal exostectomy	
a. Total	Alsberg
b. Partial	Daries-Colley, Keller, Girdlestone, Brandes, Lindemann and Meyerhof, Kaspar, McMurray, Galland and Jordan
5. Wedge resection of metatarsocuneiform joint plus plastic procedure at metatarsophalangeal joint	Riedl, Truslow, Kleinberg, Lapidus
6. Wedge resections of metatarsal neck	Hohmann, Reverdin, Mauclaire, Peabody
7. Osteotomy metatarsal shaft	Ludloff, Chlumsky, Cotte
8. Arthrodesis of metatarsophalangeal joint	Mauclaire

to the long healing time of such osteotomies. Wedge resection of the first metatarsocuneiform joint undoubtedly gives good results when done meticulously, combined with a complicated plastic procedure at the metatarsophalangeal joint. However, much more skill is required and recovery is frequently so prolonged as to make the radical cure of bunions a major procedure.

Resection of the metatarsal head, since first done by Hueter and popularized by Mayo in 1908, has been widely used in the worst cases of hallux valgus. It has the advantage of simplicity, complete correction of deformity, and shortening of the first metatarsal segment to prevent recurrence. However, removal of the first metatarsal head removes one of the important weight-bearing bones and tends to aggravate or produce an intractable metatarsalgia. Painful calluses form under the second and third metatarsal heads or stump of the first metatarsal shaft. It is well known among the laity as an operation requiring a prolonged convalescence and has added to the fear of hallux valgus operations as major procedures.

Resection of the proximal part of the first phalanx of the great toe has been proposed as an alternative procedure, to take care even of severe deformity, give a rapid convalescence, shorten the toe, and produce no fundamental changes in the weight-bearing mechanism of the foot.

REVIEW OF THE LITERATURE

The operation appears to have been done by Davies-Colley in 1887, and later by Henback and Clarke. In 1904, Keller, a United States Army surgeon, proposed this method as the standard one for dealing with hallux valgus, presenting three successful cases. His technique was essentially the same as it is done today.

Brandes, in 1928, systematized the operation and reported on over 100 cases. He did extraperiosteal resection of two-thirds of the phalanx combined with metatarsal exostectomy. Splinting was by adduction and plantar flexion, maintained by plaster. His results and after-care were very similar to what we have adopted.

Kaspar, in 1933, reported a series of 31 such operations. He used more plantar flexion to prevent dorsiflexion contractures and less adduction splintage, and he made the point that in some cases even wound infection and stiffness produced no symptoms, the patients being very happy.

McMurray, in 1936, discussed the problem of hallux valgus and presented as his most favored procedure the resection of well over one-half of the proximal phalanx. He claimed that this tended to correct the deviation of the first metatarsal from the second. He recommended subcutaneous tenotomy of the extensor hallucis longus, at a distance from the incision, in cases where this tendon appeared to be acting as a deforming force after the bone had been removed.

Lindemann and Meyerhoff in 1936 reported a follow-up study of 64 of 80 cases operated upon. Their general procedure resembled that of Brandes, but they advocated lengthening the extensor hallucis longus tendon when marked dorsiflexion of the great toe persisted after resection of the phalanx. They had 104 operations, of which 52 feet were perfect and 40 feet had mild complaints referable to existing splayfoot, flatfoot, slight valgus of the toe, or too noticeable shortening or mild dorsiflexion. The function in these was very satisfactory. In 12 cases the results were poor, due to recurrence in 4 and marked stiffness in 8, although only 2 complained of disability.

Lloyd, in 1936, reported a series of 20 cases of bilateral hallux valgus in which hemiphalangectomy was done on one side and the metatarsal head resection on the other. After one year, there was no difference, based on subjective feeling of pain only. No statement as to cosmetic or functional result was given. In addition, he did not mention the amount of phalanx resected, though a photograph showed only about one-fourth to be removed. He claimed metatarsalgia was uninfluenced by either operation and that the results of metatarsal head resection were as good as the other if one waited long enough.

Galland and Jordan presented the first paper in the American literature since Keller's on this subject, in 1938. They recommended post

operative fixation by traction in a plaster cast, by means of a silk stitch through the toe tip, for one week.

All authors who advocate partial phalangectomy emphasize the short convalescence, the rapid ambulation, and the speedy return to full working capacity, although the toe continues to improve for the first several months.

ANALYSIS OF PRESENT SERIES

Selection.—Thirty-two cases of hallux valgus and hallux rigidus had this operation at the Mount Sinai Hospital from 1935 to six months ago. Further follow-up to date has not altered the results. Concurrently, many simple exostectomies were done, so that the phalangectomized cases indicate the more severe types. This is not an end-result study, but a consideration of the Keller-Brandes operation and our experiences with it. Some of the sources of error will be presented in an attempt to improve the results. While the operation is in wide use in at least two of our orthopedic hospitals in New York, only one paper has been published in the American literature on the subject since Keller's original contribution. We believe it is deserving of more attention.

The statistics are given briefly in Table II. Most of the operations on the ward service were done by the orthopedic resident or a junior interne, under attending staff supervision, indicating the relative simplicity of the procedure. There was a slight preponderance of cases in the decades from 30 to 60 years of age, but not significantly so.

We would say now that in certain types of hallux valgus cases this operation alone is not enough. Thus, patients with a marked splayfoot,

TABLE II

55 CASES OF PARTIAL PHALANGECTOMY

No. of patients		32
Ward	24	
Private	8	
Bilateral	23	
Unilateral	9	
Male	6	
Female	26	
Age	15-69 years (evenly distributed)	
Follow-up		6 mo. to 3 yr.
Hallux rigidus		8 feet
Hallux valgus		48 feet
Reoperations (3 cases)		4 feet
Results		
Group I	17 feet	
Group II	11 feet	
Group III	10 feet	
	38 feet (70%)	
Group IV	11 feet (20%)	
Group V	6 feet (10%)	
Total	55 feet (100%)	

which is not rigid, that is, young persons, should be treated by additional measures. Two of our cases had the encircling fascial loop operation suggested by Krida. Patients with a very rigid, arthritic foot, and with marked metatarsus varus primus, so that simple exostectomy will not relieve the prominence of the metatarsal head, should have the head resected. In associated cavus or clawfeet, lengthening, transplantation, or tenotomy of the extensor hallucis longus is in order, or even midtarsal wedge resection.

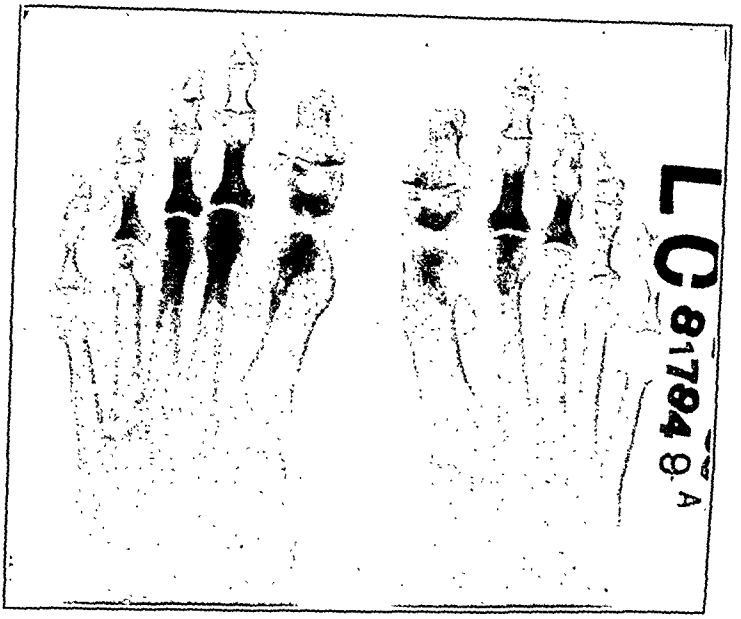

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Fig. 1.—Typical resection of two-thirds of phalanx. Good clinical result.

Points in Operative Technique.—

1. The incision may be dorsomedial or directly medial but should not be curved around a bunion. A straight incision heals better.

2. In many of our cases the phalanx was resected largely subperiosteally and the clinical results were not greatly unlike those done extraperiosteally. The former is technically much easier, although the dissection at the joint capsule must be done by sharp methods in either case. In both, care must be taken not to injure the flexor hallucis longus tendon which is very adherent to the joint capsule and base of the phalanx on its plantar aspect.

However, in a small number of the younger patients, regeneration of bone occurred in the form of spurs from the stump of phalanx or even larger pieces occupying the space left between the phalanx and metatarsal head. We are now of the opinion that extraperiosteal resection is preferable, the section of the phalanx to be made by a saw, after delivery of its proximal portion into the wound, or by bone cutting

forceps which necessitates some splintering and subsequent smoothing of the edges.

3. The amount of bone removed is the most important single factor in the entire operation. At first, only the proximal one-fourth or one-third of the phalanx was removed, but this gave poor results in the first few,

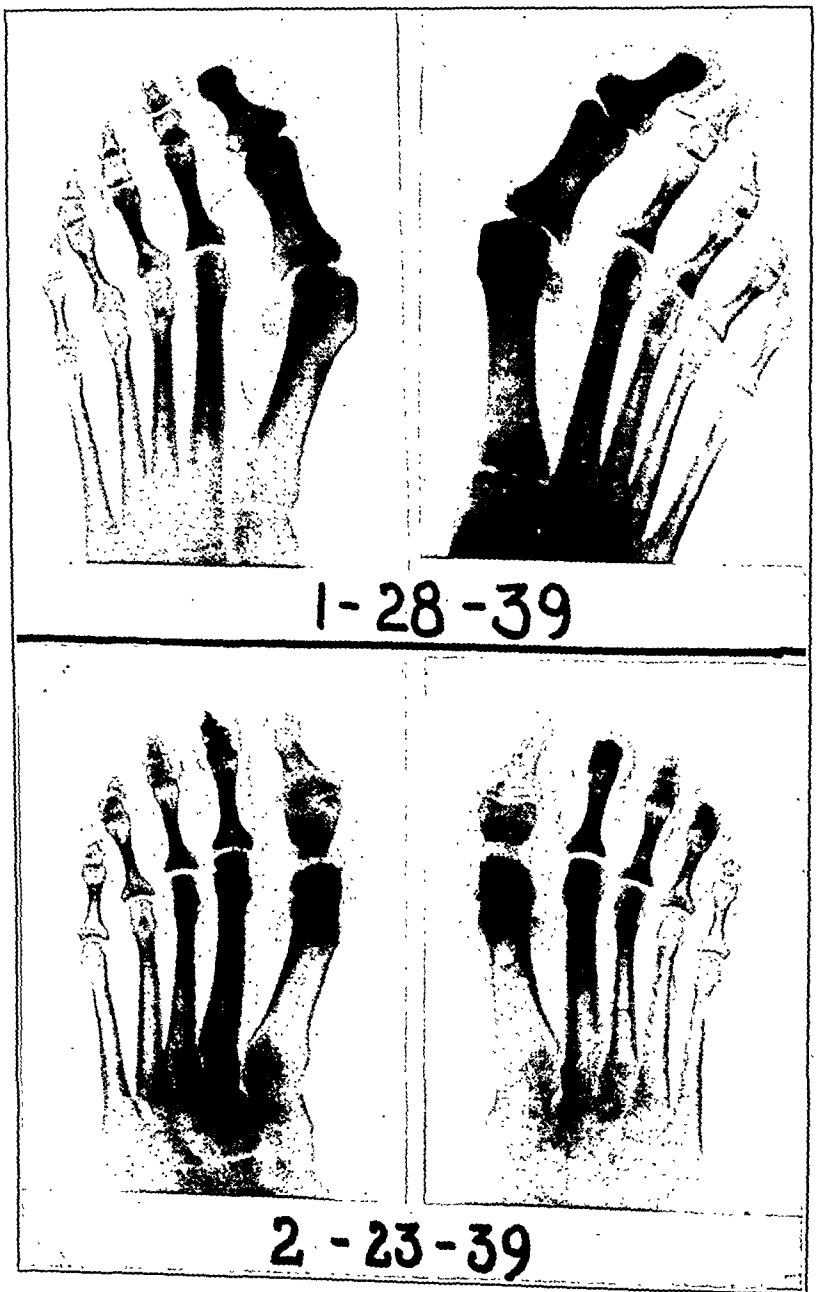


Fig. 2.—Partial phalangectomy for hallux valgus, showing cosmetic result obtainable. Excellent clinical result.

causing partial or complete fusion of the joint. Even in these, the functional result was satisfactory in most, though hardly ideal. We now resect between one-half and two-thirds of the bone. Removing less, we have the risk of stiffness and pain. Removing more, we get too much shortening of the great toe, with a less satisfactory appearance and control of the digit. Since the hallux is usually unduly long in cases of hallux valgus, a moderate amount of shortening of the great toe is an advantage and positive necessity in permanently correcting the deformity.

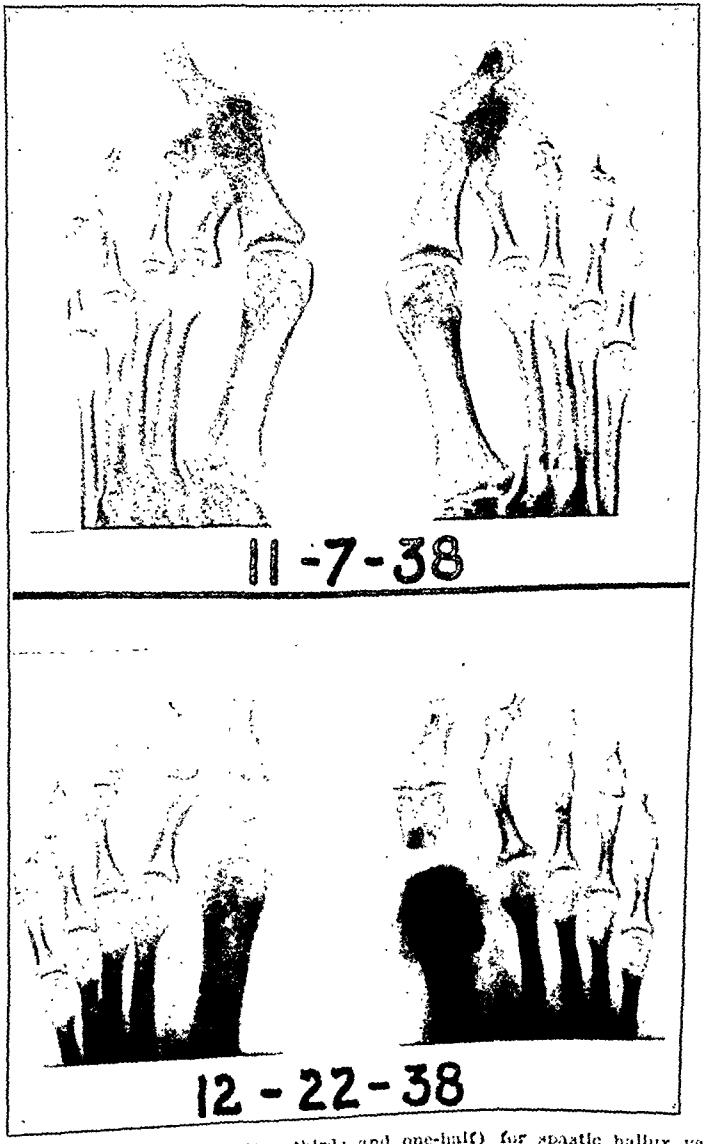


Fig. 3.—Partial phalangectomy (two-thirds and one-half) for spastic hallux valgus. Good clinical result.

4. We have attempted to cover the raw stump of phalanx, either by a flap of capsule or periosteum or by approximating the inner and outer walls of the cavity left by the bone resection. In some cases, it has not been harmful simply to close the outer fascial structures without attempting closure of dead space. The toe is very floppy at first

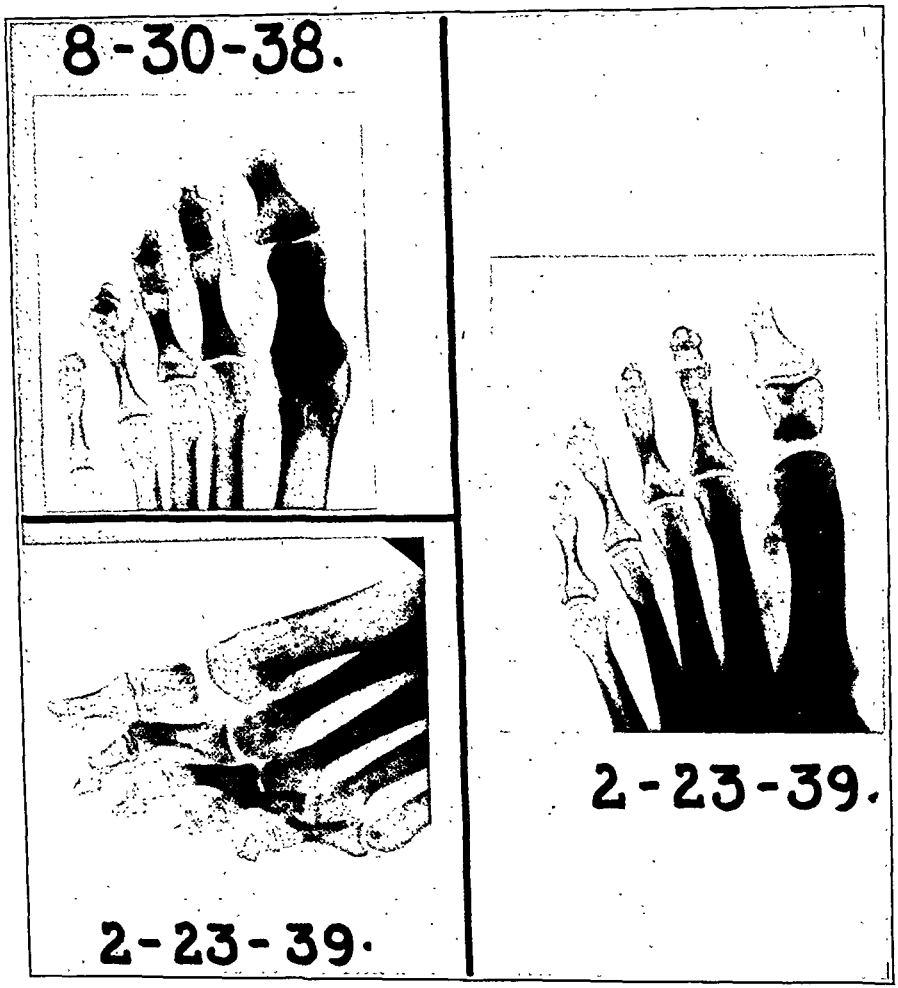


Fig. 4.—Typical partial phalangectomy for hallux rigidus. Only fair clinical result. Slightly more bone should be removed.

and has abnormal lateral mobility for some months. This does not interfere with function and the dead space is quickly obliterated as the joint tightens up. Full control of the toe occurs at about three to four months.

Points in Postoperative Care.—

1. In most of our cases, a simple sheet-wadding and bandage splint was made to maintain the toe in marked adduction and plantar flexion

for one week. This led, in 5 or 6 feet, to formation of a crease at the metatarsophalangeal joint with localized slough of skin. There was no interference with convalescence other than the necessity to maintain a dressing for four to five weeks. In most of the cases this did not happen, and we believe that fixing the toe in but slight adduction and plantar flexion will prevent this. We used fixed traction with a

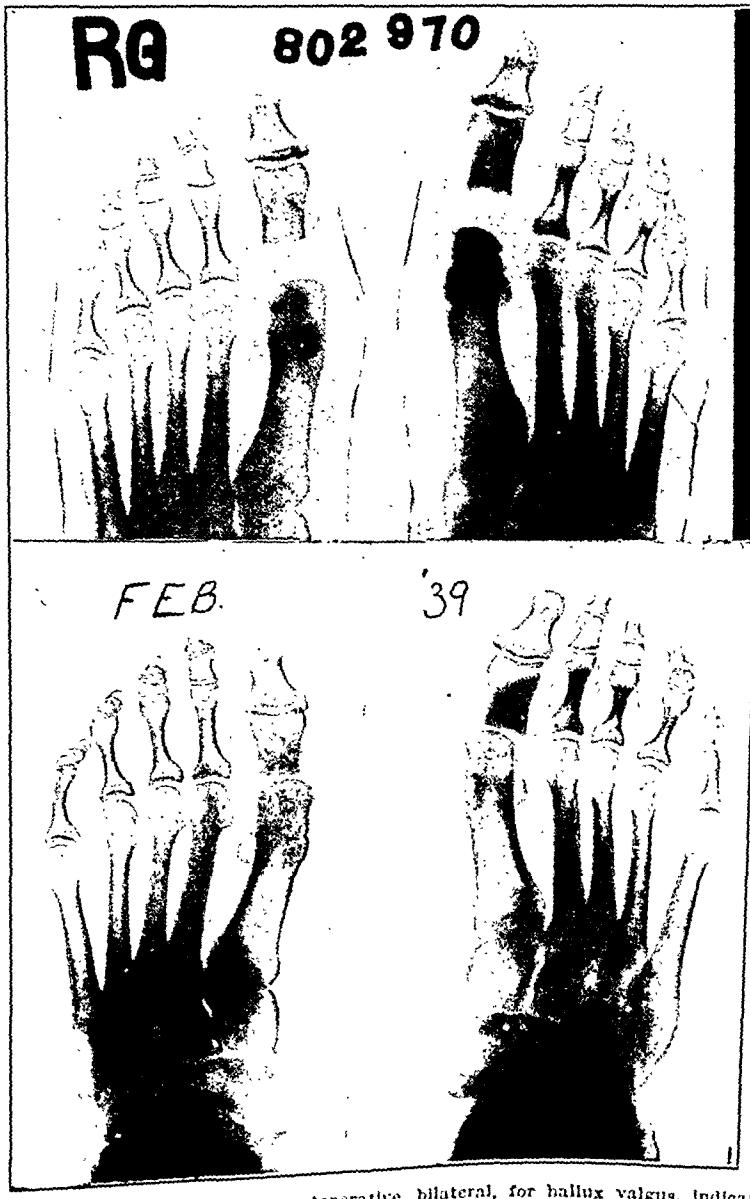


Fig. 5.—Hemiphalangectomy, postoperative, bilateral, for hallux valgus, indicating the tightening up of the originally extremely lax joint. February, 1938, immediately postoperative. Excellent clinical result.

stitch through the toenail in several cases with no difference in convalescence.

2. No significant wound infections occurred, although one sinus after a skin slough persisted for a few weeks. The only other complications were a single case of phlebitis and an intercurrent mild respiratory infection.

3. After one week to ten days, the toe is allowed to return to the neutral position. The patient is out of bed in a week, walking by the end of two weeks with a cutout shoe, and discharged from the hospital.

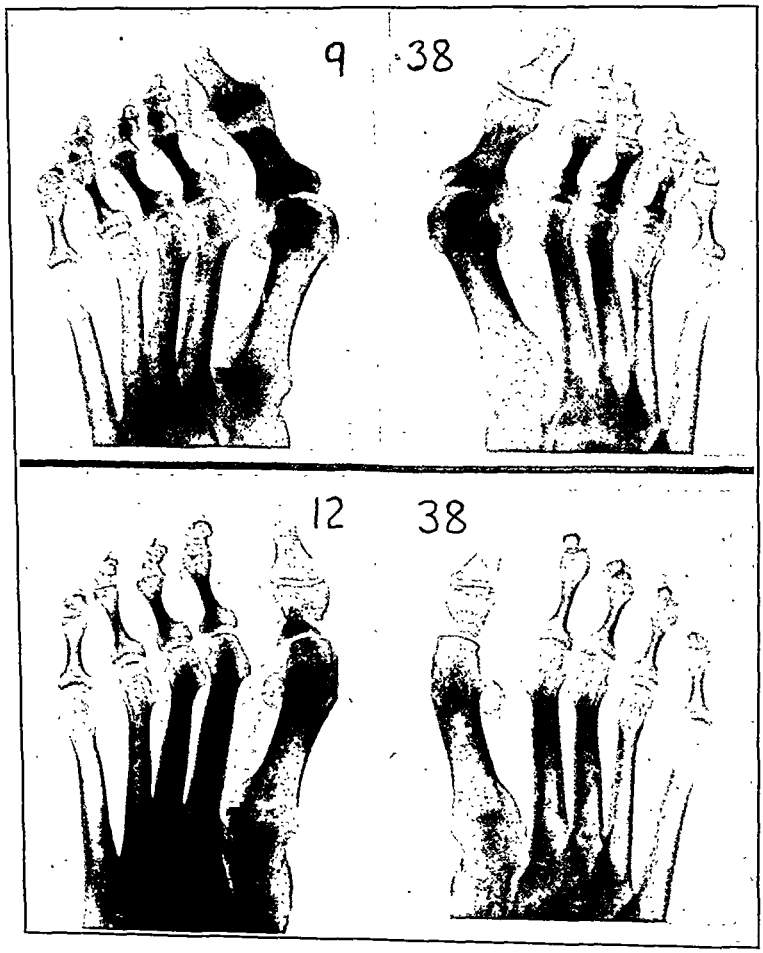


Fig. 6.—Partial phalangectomy (two-thirds) in a young girl, resected subperiosteally. Note bone regeneration in new joint space, bilaterally, left much more than right. Fair clinical result.

4. In the last one-half of the cases, the forefoot has been supported in most cases by a circular compression dressing of zinc gelatin bandage or adhesive for a period of weeks. About one-half the patients used metatarsal arch supports for some months.

5. Most of the patients were back on full duty or full activity in three to four weeks, doing such things as general duty nursing, waiting on table, playing golf, etc. By the end of six weeks, practically all were restored to their usual activities.

RESULTS

In evaluating any procedure, much depends on the criteria used by the man rating the cases. These were divided into five categories:

Group 1, Excellent.—No pain was present in the great toe. There was normal, or practically normal, motion with no aggravation of long arch or metatarsal pain, with perfect cosmetic result. Seventeen feet were of this type.

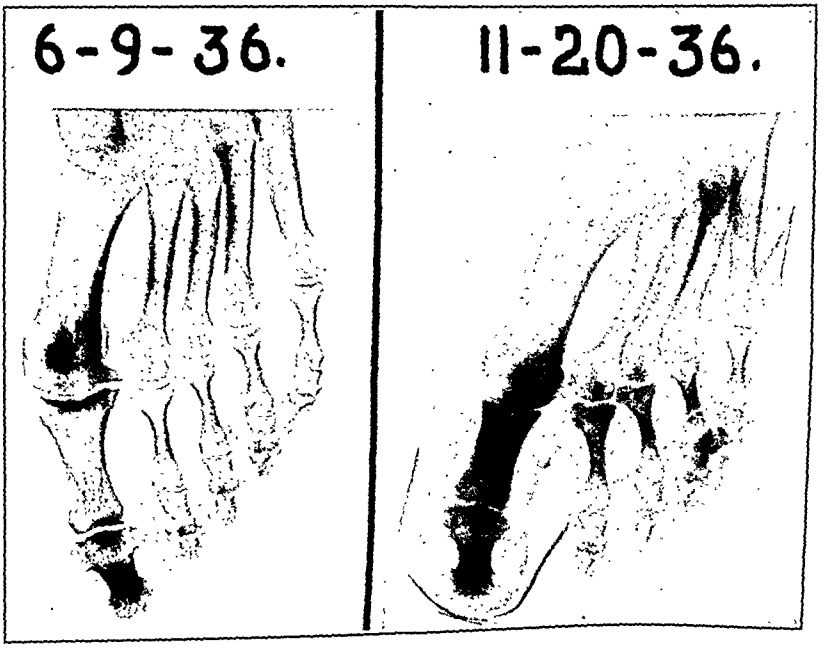


Fig. 7.—Insufficient bone resection for hallux rigidus; one of our first cases. Fibrous ankylosis and a poor result occurred.

Group 2, Good Results With No Details.—This group included those in which I did not personally examine the feet in follow-up, mainly being private cases of the other men on the staff. None of these had symptoms remaining after operation; all had good motion and perfect cosmetic result. Ten feet were of this type.

Group 3, Good.—In this group were included those with no or slight occasional discomfort in the new joint, slight limitation of motion, tendency to dorsiflexion of the great toe when at rest; or those with slight recurrent or persisting hallux valgus, but with the toe not at all or slightly shorter than the second toe. Eleven were such feet.

Group 4, Fair.—This group covers those greatly improved by the operation, with the patient satisfied, but with some specific defect, such as (a) some pain in the articulation, (b) considerable limitation of motion, (c) permanent dorsiflexion of great toe, (d) aggravated metatarsal or long arch pain, (e) too noticeable shortening of the toe, or (f) too much regeneration of bone. Eleven feet were of this type, the greater number being due to limitation of motion and slight dorsiflexion contracture of the toe, accompanying a general tendency to mild or moderate clawing of all the toes and prominence of the metatarsal heads.

Group 5, Poor.—Those with too much pain, fibrous ankylosis, or much worse metatarsalgia or long arch pain are included here. Only six feet were of this type.

DISCUSSION

Grouped together, 38 of 55 feet, or 70 per cent, were excellent or good; 11, or 20 per cent, were fair; and only 6, or 10 per cent, were failures. These results compare favorably with almost any type of hallux valgus operations where true attempt is made to correct the deformity permanently. They resemble the reported German results.

The future results should be even better. Most of the poor results were in the earliest cases where not enough bone was resected. Several of the poor and fair results occurred in patients with marked deformity, but without preoperative pain in the bunions. In such patients, the possibility of slight postoperative symptoms should be discussed before embarking on cosmetic surgery.

In our hallux rigidus cases especially, the tendency was not to remove enough bone as there was no deformity to correct. Of 7 such cases, the first 3 in our series were poor on account of this. Two were fair and 2 were good or excellent. In view of the great stiffening tendency, probably more bone should be resected than in hallux valgus, but in unilateral cases the difference in great toe length should be discussed with the patient beforehand.

Reoperations.—Three cases had secondary operations, approximately one year after the first. One was a bilateral hallux rigidus case which developed postoperative ankylosis due to insufficient bone removal. Reoperation produced a better result but the follow-up is insufficient to include this. The other two, also bilateral, were operated upon for residual pain with restriction of motion in one toe. In each case, the result was fair but the patient wanted it to equal the other foot, which was perfect. Removal of a further small amount of bone in these cases produced an excellent result in one and a fair result in the other, where the joint space and metatarsal head were fused with the phalanx by a mass of fibrous adhesions. Three other poor and fair cases have been advised operation, another advantage of this procedure.

X-Ray Findings.—In no case in which we had pre- and postoperative films to compare was there an increase in the width of the foot or splayfoot. The feet were diminished in width by the exact amount of exostosis removed from the first metatarsal head. The films were not made in weight bearing, however.

McMurray states that after partial phalangectomy the angle between the first and second metatarsal segments, so commonly increased in hallux valgus, tends to decrease. Measurements in fourteen of our cases did not confirm this.

Measurement of the metatarsophalangeal angle, as an expression of the correction of hallux valgus, showed much correction in all cases, averaging 20 degrees. This measurement had no direct relationship to the gross cosmetic result. Some feet with relatively few degrees of correction showed an excellent cosmetic appearance. The more severe the hallux valgus before operation and the larger the angle, the greater correction was obtained in degrees. Lumping all cases, the postoperative average angle was 22.5 degrees, and yet many of the cases showed a perfect cosmetic appearance.

CONCLUSIONS

1. Partial phalangectomy plus exostectomy of the first metatarsal head is a simple, efficient operation for the radical cure of ordinary, severe hallux valgus and hallux rigidus, provided proper attention to detail is given.

2. Extraperiosteal resection of one-half to two-thirds of the phalanx should be done in hallux valgus. In hallux rigidus nearer two-thirds should be removed.

3. A simple pressure dressing in the neutral position will prevent creases and the possibility of a slough in the incision.

4. The forefoot should be supported by a circular compression dressing for some weeks, and followed, if necessary, by metatarsal arch supports.

5. If these details are observed, eminently satisfactory results will be obtained. Convalescence should be rapid, with painless walking in two weeks, and return to full activity in three to five weeks. Laxity of the joint will disappear in three to four months.

6. Symptoms due to other associated foot conditions will not be altered by any hallux valgus operation.

I wish to thank Dr. Seth Selig, Dr. Robert K. Lippmann, and Dr. Edgar Bick for the privilege of studying their cases, ward and private.

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PRINCIPLES GOVERNING THE TREATMENT OF FRACTURES AND BONE LENGTHENING BY DIRECT SKELETAL MEANS AND A NEW APPARATUS

Preliminary Report

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FRACTURES and their management have been of deep and universal interest to the medical profession for many centuries. Records dealing with their study may be found to go back to the Egyptians of 4,500 years ago, and the basic principles underlying our present-day management of acute closed fractures were laid down by Hippocrates as long as 2,000 years ago. It is interesting to note that the various methods and devices for early treatment recommended by Hippocrates remained virtually unchanged until the nineteenth century, when Sir Ashley Cooper's "Treatise on Dislocations and Fractures of the Joints" opened a new path and stimulated renewed interest in the subject.

The important result of this was the first step in the development of our knowledge of the treatment of acute fractures by direct skeletal means.

The purpose of this paper is twofold: (1) to enlarge upon the principles of this significant development, as a result of the knowledge gained by the use of this form of therapy in more than sixty cases of bone lengthening and fractures; (2) to present a new apparatus based directly upon these principles.

There is little doubt that the management of acute fractures by direct skeletal means is a distinct contribution to the care of the maimed. This form of therapy, the result of slow arduous endeavor by the masters of the past century, has brought about a change in our philosophy of the management of acute fractures. The dictum as propounded by Hippocrates "extension of fractured or dislocated bones is not to be delayed to the third day, but is to be carried out on the first day," or better, immediate or early treatment, is no longer sufficient because the word ambulatory is lacking. The key-note of treatment today is immediate or early ambulatory treatment in properly selected cases. For acute fractures, otherwise extremely difficult to manage, may now be immediately and easily reduced and may readily be made ambulatory by direct skeletal means.

Barton laid the foundation of this science when he wired acute fractures of the patella in 1834, although Moreau, in France, had un-

Received for publication, August 3, 1939.

successfully treated cases of nonunion by this means in 1805. Thus, internal fixation was the first cardinal principle of the treatment of acute fractures by direct skeletal means. Further development of our knowledge progressed rather slowly; approximately 100 years elapsed before Codivilla, in 1903, introduced skeletal traction by driving a steel carpenter's nail through the os calcis for a fracture of the femur. This was a great advance, for, as pointed out by Codivilla, "no longer need one expect terrific skin sloughs so commonly encountered following the use of external spicas to maintain distraction." It was soon seen that skeletal traction was most efficient when applied to the bone involved. Ombredanne, though unsuccessful, was the first to attempt a skeletal traction apparatus. It remained for Putti to succeed in this accomplishment when, in operative lengthening of the femur, he used one pin to suspend each fragment. In 1927 an American orthopedic surgeon, Abbott, put the matter upon a more practical basis when, in operative lengthening of the tibia with a four-pin device, he used two pins to suspend each fragment. With the appearance of his writings, added impetus was given this absorbing subject.

In 1932 a four-wire, leg-lengthening device was described, with the following innovations[1]:

1. The apparatus used Kirschner wires (introduced in 1909) instead of the heavier Steinman pins, thereby diminishing the possible danger of introducing infection.

2. The device had vertical uprights to grasp the wires. Thus the extremity was readily accessible, and plaster of Paris could be easily applied with the apparatus in situ.

3. It had means of correcting any change in the angular relationship between the fragments of a severed bone.

However, a disadvantage of this apparatus was that it manipulated the fragments of a severed or broken bone at pivotal points away from the point of severance.

Soon several other apparatuses employing skeletal suspension and skeletal traction were introduced for the reduction of fractures. They did a great deal to popularize the immediate mechanical fluoroscopic means of reducing fractures otherwise extremely difficult to manage. However, these devices, too, manipulate the fragments from two pivotal points away from the site of fracture and employ the two-pin method of suspension (one pin through each fragment).

Another apparatus is here presented for the treatment of fractures and for bone lengthening. It is not presented merely as something new, but rather as something different in principle. This device suspends the proximal fragment in a definite immovable position and manipulates only the distal fragment at a pivotal point at the site of fracture, thereby aligning and effecting reduction with the least amount of trauma. The four-wire method of suspension is specifically

recommended; i.e., two wires through each fragment. The apparatus further provides an easily controlled precise method of reducing fractures otherwise extremely difficult to manage by other than completely open means. With the apparatus presented, a closer and more accurate apposition of the fractured ends of the broken bone may be obtained, thus favoring a more rapid union and shorter convalescence. A description of the apparatus will follow later. It is to be noted here that the apparatus is based upon the principles which are believed to be applicable to any method of treatment of a fractured or severed bone with displacement of the fragments. These principles are as follows: (1) immediate or early ambulatory treatment, (2) suspension, (3) traction, (4) manipulation and reduction, and (5) fixation and immobilization.

1. *Immediate or Early Ambulatory Treatment.*—It is believed that the time is not very far removed when certain types of fractures will not be seen occupying beds in traumatic wards. Immediate or early refers only to the time interval between the incidence of fracture and institution of treatment.

2. *Suspension.*—Suspension is perhaps the all-important basic principle in the treatment of a broken or severed bone. A broken or severed bone is usually in suspension from the moment the extremity is raised until it is returned to a position of rest. When the fragments of a broken bone are suspended, let us assume a constant fixed relationship between each suspending object and its fragment of bone. Then, should the suspending objects be distracted and so maintained, then the fragments will be distracted. Should the suspending objects be manipulated in such a way as to reduce the fracture and be so maintained, then the fracture will remain reduced. When fixation of the fragments and immobilization are executed and suspension is discontinued, the limb may be returned to a position of rest. Two conclusions may be drawn from the foregoing:

A. The treatment of a fracture with displacement of the fragments is dependent chiefly upon suspension with a fixed constant relationship between the suspending object and its fragment of bone; i.e., adequate suspension. Adequate suspension includes ready accessibility of the broken extremity.

B. With adequate suspension and sufficient force properly directed upon the suspending objects, the treatment of a fracture becomes a comparatively simple problem.

Thus the treatment of a fracture by direct skeletal means is chiefly dependent upon adequate suspension.

If the time consumed by suspension in the treatment of a broken bone is graphically represented, an interesting comparison is revealed (Fig. 1).

The time consumed by the execution of each of the above principles varies, of course, in different cases, but, as indicated above, the length of time consumed by suspension is always greater than the sum total of the time consumed by the execution of the remaining principles. This is, I believe, true, regardless of the method used in the treatment of a broken or severed bone, because suspension is in force during traction, manipulation, reduction, fixation, and immobilization.

Theoretically, adequate suspension by direct skeletal means may best be accomplished by passing four wires through a suitable fragment of bone, two in a horizontal plane and two in a vertical plane, separated as far as possible. By this means, vertical or lateral mobility and angulation are rendered impossible. However, a practical, efficient, and thoroughly proved plan of adequate suspension merely requires the use of two wires drilled through a suitable fragment of bone and separated as far as possible. Padded metal shields are placed firmly against the involved extremity and fixed to the wires. Thus, vertical or lateral mobility and angulation are eliminated.

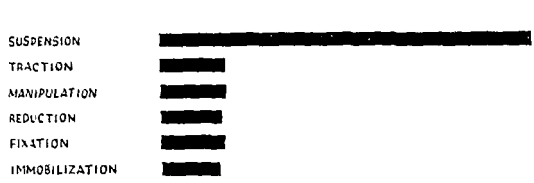


Fig. 1.—Graph showing schematic presentation of the time consumed by the principles employed in the treatment of a broken bone.

Adequate suspension is, I believe, the all-important basic principle in the therapy of fractures by direct skeletal means. It has been my experience that the gravest pitfalls lie in inadequate suspension. It is in inadequate suspension that most errors are made, with their subsequent untoward consequences. One wire through a fragment of bone merely acts as a pivot. At least two wires inserted in accordance with the above principles are necessary to adequately suspend a suitable fragment of bone. Only thus can vertical or lateral mobility and angulation be eliminated and infection, deformity, and pressure necrosis prevented.

3. *Traction.*—All things being relative, a linear displacement of one of the fragments of an adequately suspended broken or severed bone will suffice to alter the relationship between the two fragments.

4. *Manipulation and Reduction.*—What has been said under the heading of traction also applies to manipulation. Only one fragment need be manipulated to alter the relationship between the fragments of a severed or broken bone. Bringing the distal fragment in line with the upper has been the method preferred to date. I believe, however, that bringing the distal fragment in line with the upper with the center of rotatory motion at the site of fracture is actually the better method

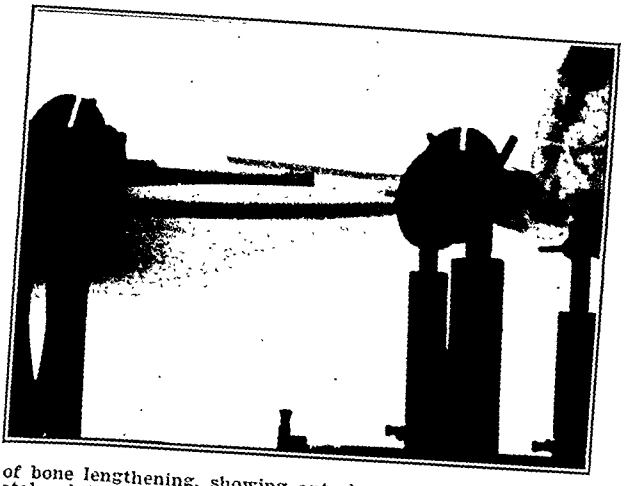


Fig. 2.—Case of bone lengthening, showing anterior angulation of the fragments with the pivotal point of motion at the distal end of the proximal fragment.

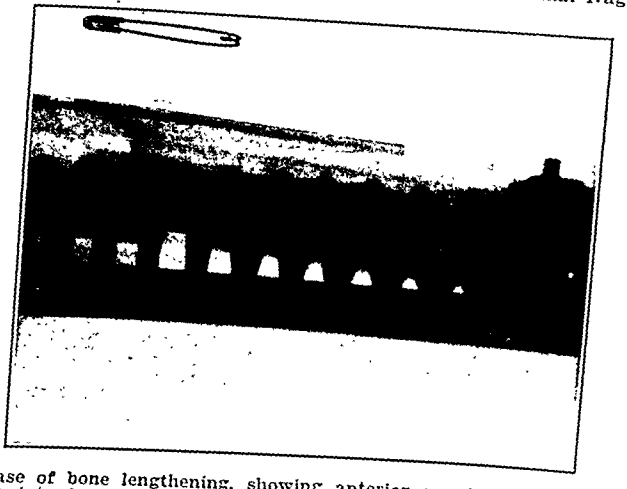


Fig. 3.—Case of bone lengthening, showing anterior angulation of the fragments with pivotal point of motion at proximal end of distal fragment. Note soft tissue shadow of calf, indicating that knee is to left side of page.

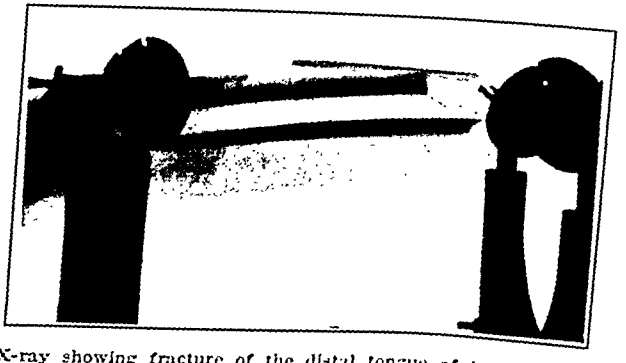


Fig. 4.—X-ray showing fracture of the distal tongue of bone in a case of bone lengthening following an attempt to correct anterior angulation of the fragments. A direct result of undue pressure because distal fragment was manipulated at a point away from the distal end of the proximal fragment.

of manipulation. In one case the center of motion may be at the distal end of the proximal fragment and in another at the proximal end of the distal fragment, as seen in Figs. 2 and 3.

When the center of rotation is moved away from either of these points, the amount of motion is increased at the site of fracture. This results in additional trauma and may also mean serious injury to some vital soft tissue structure or bone. However, by placing the center of motion at the distal end of the proximal fragment or at the proximal end of the distal fragment, as the case requires, there is the least amount of motion at the site of fracture. The method of manipulation is therefore extremely important.

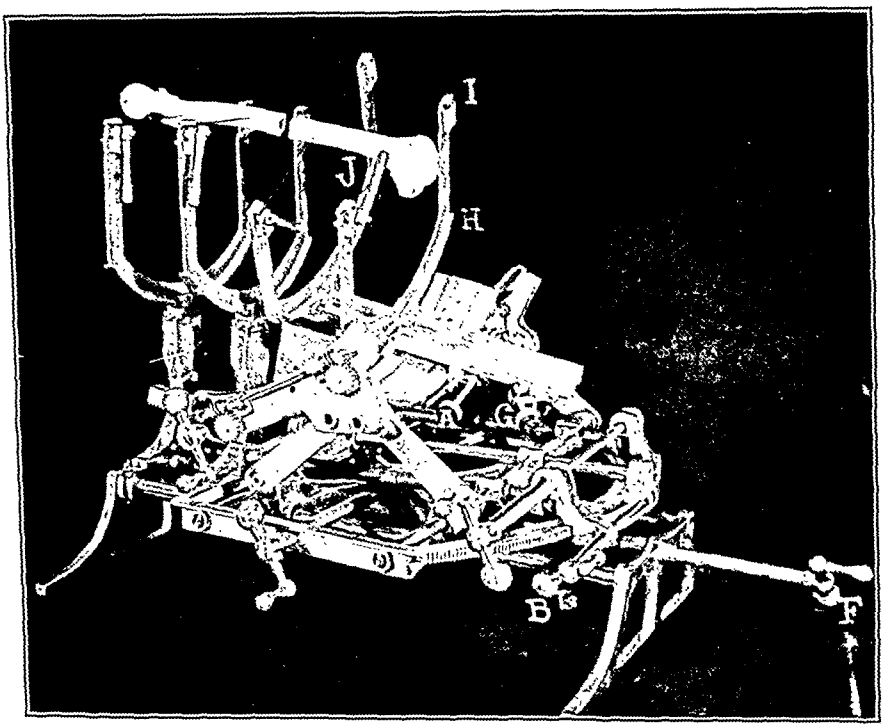


Fig. 5.—*A*, Knob for axial rotation of distal fragment; *B*, handle for pivoting distal fragment in a horizontal plane at a point at the distal end of the proximal fragment or at the proximal end of the distal fragment, as the case requires; *C*, handle for a pivoting distal fragment in a vertical plane at a point at the distal end of the proximal fragment or at the proximal end of the distal fragment (see Fig. 6).

On reduction, the consensus is in favor of absolute anatomical realignment of the fragments.

5. *Fixation and Immobilization.*—If the fragments are adequately suspended in accordance with the above principles, fixation is readily applicable. A proved method of fixation has been described in the article previously referred to. The method employs both internal skeletal and external fixatory means. Possible displacement of the fragments is thereby reduced to a minimum, thus practically eliminating resulting pressure

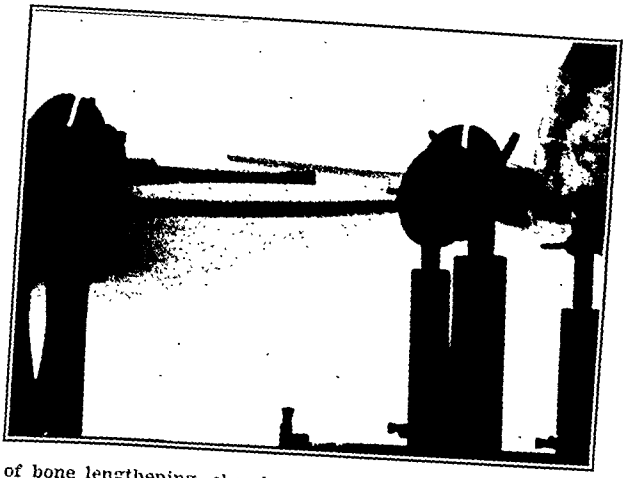


Fig. 2.—Case of bone lengthening, showing anterior angulation of the fragments with the pivotal point of motion at the distal end of the proximal fragment.

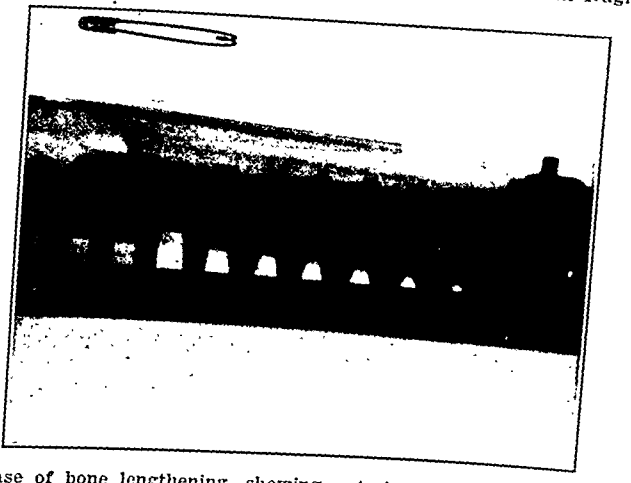


Fig. 3.—Case of bone lengthening, showing anterior angulation of the fragments with pivotal point of motion at proximal end of distal fragment. Note soft tissue shadow of calf, indicating that knee is to left side of page.

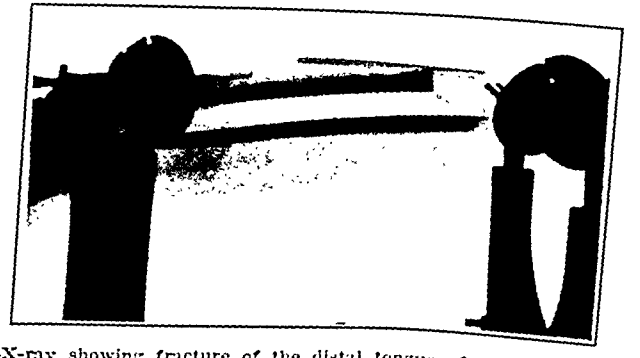


Fig. 4.—X-ray showing fracture of the distal tongue of bone in a case of bone lengthening following an attempt to correct anterior angulation of the fragments. A direct result of undue pressure because distal fragment was manipulated at a point away from the distal end of the proximal fragment.

and longitudinally. The undercarriage suspending the distal fragment is further capable of exerting traction. Thus, the distal fragment may be brought in line with the proximal fragment about a point of universal motion at the distal end of the proximal fragment or at the proximal end of the distal fragment. With this apparatus, therefore, a fracture may be reduced with the minimum amount of motion (and resulting trauma) at the site of fracture.

This is the main feature distinguishing the apparatus presented from all other fracture devices heretofore used.

Handles *A, B, C* (Fig. 5), respectively, combined afford universal point of motion at the desired point at the site of fracture. This point of universal motion may be adjusted vertically by *D*, laterally by *E*, and longitudinally by *F*. Knob *G* is for traction or lengthening; Clamp *H* with wire tensioning device *I* and *J*. *I* grips wire automatically if the wire is pulled in the direction of Handle *G*, which tenses wire by simply turning it in a counter-clockwise direction. The apparatus is 30 inches long, 24 inches wide, and 22 inches high. It weighs approximately 75 pounds. The dimensions have been chosen so that it may be used to treat a fracture of the femur as well as the smaller portions of either upper or lower extremity. Its main disadvantage is its height as it necessitates the additional use of an adjustable platform and pelvic rest for the patient. There are other unimportant minor disadvantages, but these readily may be overcome by slight changes in design.

CONCLUSION AND SUMMARY

A more detailed description of the apparatus and case reports will form the basis of a future publication. In addition there will be more detailed technical descriptions relative to bone lengthening and fractures in a more practical light. This paper, presented purely as a preliminary report, deals only with basic principles and presents a new apparatus.

REFERENCE

1. Haboush, Edward J., and Finkelstein, H.: Leg Lengthening With New Stabilizing Apparatus, J. Bone & Joint Surg. 14: 807, 1932.

necrosis and permitting safe early weight-bearing. Danger of introducing infection by displacement of the fragments on the wires is also practically eliminated by the above method.

If fixation of the fragments of a severed or broken bone is absolute, immobilization is superfluous. For this reason, for the sake of clarity, it is perhaps best to confine the meaning of immobilization to the locking up of contiguous joints.

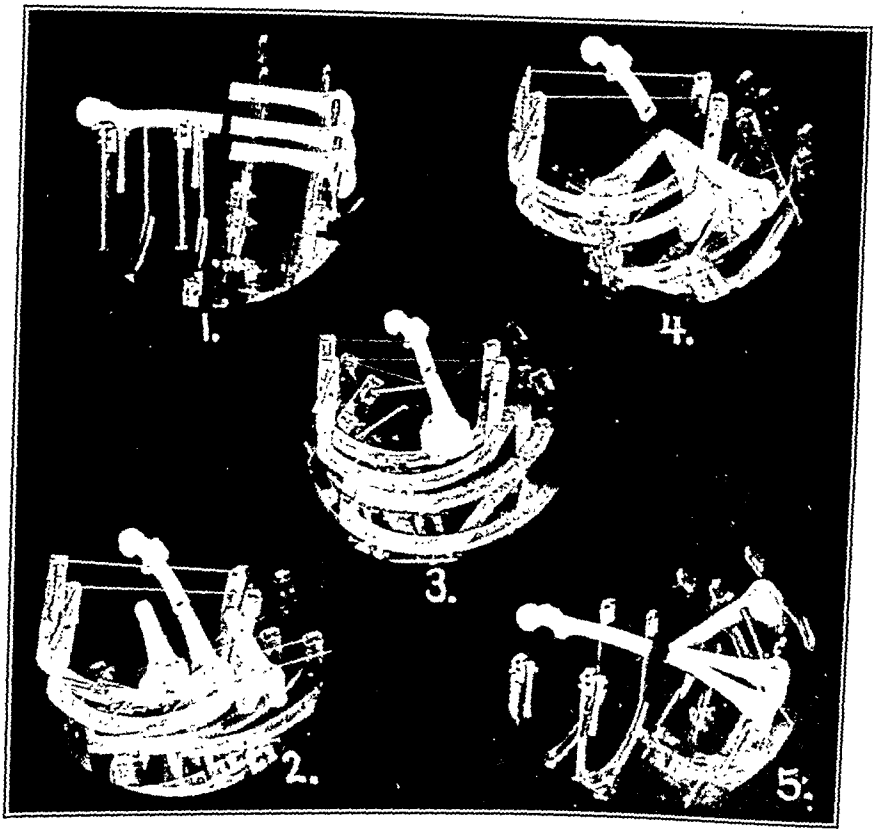


Fig. 6.—*1*, Vertical motion; *2*, lateral motion; *3*, axial rotation; *4*, horizontal pivotal motion; *5*, vertical pivotal motion.

APPARATUS

In accordance with the above principles, the apparatus presented is designed for the adequate suspension of the fragments of a broken or severed bone. The apparatus is capable of grasping multiple wires at any angle in space. It suspends the proximal fragment in a definite immovable position. The distal fragment is suspended by an undercarriage with a remotely controlled point of universal motion, which may be placed either at the distal end of the proximal fragment or at the proximal end of the distal fragment. This point of universal motion may thereby be adjusted in cubic space; that is, vertically, laterally,

connected with it by a short rubber tube; (2) using a segment of jejunum attached to the stomach at its lower end and its upper end (a) brought through a tunnel under the skin to the esophageal fistula or (b) to the lower end of a skin tube going up to the esophagus; (3) using a segment of the transverse colon in a similar way; (4) making a tube from the lesser curvature of the stomach, leaving it attached to the stomach at one end and bringing up the other end as in the case of the jejunal segment; (5) using the entire stomach as a tube and bringing it through a tunnel under the skin to the esophageal fistula.

Most of these procedures have been done in Europe and the mortality has ranged from 22 to 66 per cent, depending upon the method used. In this country one case has been reported by Ochsner for benign stricture in which he used the jejunodermatoesophagoplasty method, and one each by Eggers[2] and Garlock[3] for malignant stricture in which they used the rubber-tube dermatoesophagoplasty method. These patients all recovered and had good functional results. In the first case, six different stages were required and during part of the time the patient was in desperate condition. In the case of Eggers three stages were required and the procedures seemed less dangerous, while in the case of Garlock a short skin tube was connected to a low-lying esophageal fistula. Several other cases have been reported in which an upper esophagostomy was done for malignant disease lower down and the esophageal fistula joined to the gastrostomy wound by a rubber tube. This was first done by Torek in 1913[4] after a successful resection of a cancer of the esophagus.

We wish to report a second case, in which an artificial extrathoracic esophagus was constructed for benign stricture.

Mrs. H. C., aged 24 years, was first seen Dec. 5, 1927. Nine weeks previously she had burned her face and throat with a strong fluid. Since then she could only swallow fluids and very soft food and such swallowing was painful. Nothing abnormal could be seen in the pharynx, but a stomach tube did not pass more than 8 inches from the teeth. An x-ray examination showed an irregular constriction of the esophagus just above the aortic arch. The esophagus above this point was dilated to a width of about 1½ inches. A slight amount of barium trickled through the obstruction.

Attempts were made to pass bougies, but were not successful, and another x-ray taken a week later showed practically complete stricture. She was admitted to the Deaconess Hospital and on Dec. 20, 1927, a gastrostomy was done under local anesthesia by the method of Stamm. Convalescence was rather prolonged and further attempts to get through the stricture were not considered advisable until Feb. 23, 1928, when Dr. Morris Newman performed an esophagoscopy. This was repeated several times, both from above and below, but all attempts to get through the stricture were unsuccessful. A number of attempts to swallow a thread were also unsuccessful.

However, on April 17, 1928, a fine filiform bougie was finally passed through the stricture, followed by a long silver probe. During these manipulations, the patient developed a high temperature and they had to be stopped, although by this time

ARTIFICIAL SKIN-LINED ANTETHORACIC ESOPHAGUS FOR IMPERMEABLE STRICTURE

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THE conditions in which the construction of an artificial esophagus is indicated are so rare that very few cases have been reported. However, where these conditions do exist, this operation makes it possible for an individual who has been condemned to a life of more or less isolation because of inability to partake of food in the company of others to again take a place at the family table with its attendant sociability and to enjoy the actual taste of food. Surely this is a most desirable accomplishment and well worth the patience required of both patient and surgeon to bring this about.

The condition for which esophagoplasty is indicated is stricture of the esophagus. This may be benign or malignant. In the case of benign stricture most cases can be cured by gradual dilatation of the stricture and by keeping it dilated by periodic passing of bougies. It is only in those cases in which a stricture is absolutely impermeable or so extensive that it cannot be dilated that an esophagoplasty should be considered, and then only after every possible conservative method of cure has been tried, including direct and retrograde esophagoscopy, passing of filiform bougies, swallowing of string, etc. In the case of malignant stricture, only those cases should be considered in which the cancer has been removed and a recurrence is unlikely.

Thus the field for this operation is very limited, for most benign strictures can be dilated and thus far only a few cases have been reported in which a carcinoma of the esophagus has been successfully removed.

The various methods employed and their successes and failures have been very carefully described and the literature on the subject summarized by Oehsner and Owens in 1934.[1] In brief, they include an esophagostomy in the lower part of the neck, bringing the divided end of the esophagus proximal to the stricture to the surface of the body. In the case of a malignant stricture, this has already been done in the original operation for resection of the cancer. In cases in which the upper end of the esophagus is long enough, it may be brought farther down on the chest wall through a tunnel under the skin, as described in a case by Garlock.[3] This esophageal fistula is then connected to the stomach by one of the following methods: (1) Construction of a skin tube going down almost to a gastrostomy wound and

Received for publication, August 2, 1939.

cricoid cartilage to the sternum. The sternomastoid muscle and carotid sheath were retracted laterally and the left ribbon muscles and lobe of the thyroid medially. A greatly dilated esophagus, about 2 inches in diameter, then came into view which was bluntly and quite easily separated from the trachea in front and the spinal column behind. The left recurrent nerve was visualized, running along the trachea, and was not injured.

After separating the esophagus from its adjacent structures and well down into the mediastinum, about 2 inches below the upper border of the sternum, a silk ligature was applied at the lowest possible point and a curved clamp about 1 inch above it. The esophagus was divided between the two and the stumps sterilized with tincture of iodine. The lower stump was allowed to drop into the mediastinum and two small iodoform tampons inserted down to the stump. The lower end of the upper



Fig. 2.—Esophagostomy completed and rubber tube connecting esophageal and gastric fistulas.

esophagus was then brought out to 1 inch beyond the skin edge and sewed to the lower end of the wound with interrupted chromegut sutures. The fascia was closed around the esophagus and tampons with interrupted chromegut and the skin with Michel clamps and a few silk sutures. The clamp at the end of the esophagus was replaced by a linen suture. Time of operation, one hour and fifteen minutes.

The postoperative course was quite mild, but the wound in the neck became infected and discharged a foul-smelling pus. Smears taken on April 6 and May 2 showed numerous spirella and a moderate number of fusiform bacilli. Four doses of 0.3 gm. neosalvarsan were given intravenously and the wound soon became clean. Patient left the hospital on May 7 with a tube connecting the esophageal fistula with the gastrostomy wound (Fig. 2).

the patient could swallow liquids. By August, 1928, she could swallow fluids satisfactorily; the gastrostomy tube was removed and the wound allowed to heal.

In May, 1929, swallowing again became difficult, attempts at passing a probe were unsuccessful, and x-ray examination at this time showed complete obstruction (Fig. 1). She was readmitted to the hospital and on May 16, 1929, a second gastrostomy was performed by Dr. E. T. McGroder.

Following this, she became well nourished and felt fine, feeding herself entirely through the gastrostomy tube. At this time an artificial esophagus was proposed to her but refused.



Fig. 1.—Roentgenogram taken May, 1929, showing complete obstruction and dilatation of esophagus above it.

In April, 1934, an appendectomy was done without any difficulty.

In March, 1938, the patient returned and said that she was tired of taking her food through her gastrostomy tube, that she was anxious to eat like other people, and that she was willing to submit to any procedures that would bring this about. Accordingly we admitted her to the hospital and proceeded to do the first stage.

First stage, esophagostomy, was performed March 19, 1938. An incision was made along the anterior border of the left sternomastoid muscle from the level of the

The skin on each side of this area was undermined and the edges were brought together over the new-formed tube by means of two tension sutures passing beneath the tube and through buttons on each side. The edges were then sutured with interrupted silk and a few silkworm-gut sutures. The transverse incisions which had been made at the ends of the vertical incisions were closed with clips and silk sutures. There was no difficulty in bringing the skin flaps over the new-formed tube. (Fig. 3.)



Fig. 4.—Artificial skin-lined esophagus along front of chest. Upper end connected to esophageal fistula and lower end to gastric fistula by means of rubber tubes.

While the wound of this operation healed primarily, convalescence was attended by a chill on the tenth day, followed by temperature of 104° F. and eventual formation of an abscess in the neck near the esophageal fistula. This was incised on July 12, with discharge of pus, but showing no bacteria on smears or growth on culture. The patient left the hospital on July 24 with all wounds healed and able to swallow liquids by connecting the upper end of the skin tube with the esophageal fistula and the lower end with the gastric fistula by means of short rubber tubes. (Fig. 4.)

On Sept. 15, 1938, patient re-entered hospital for the final stage.

Third stage, *construction of additional skin tube to connect* upper end with esophageal fistula, was performed Sept. 17, 1938. Two vertical incisions were made between the levels of the esophageal fistula and the upper end of the antethoracic esophagus, about three inches apart, and corresponding horizontal incisions were made toward the middle from the ends of the vertical ones, making two flaps, which were undermined and sewed together anteriorly by two rows of sutures as was

Patient re-entered the hospital June 7, 1938. The wound in the neck was well healed and working properly.

Second stage, partial construction of antethoracic esophagus, was performed June 9, 1938. Two vertical incisions were made three inches apart on the front of the chest from the level just below the esophageal fistula to a level just above

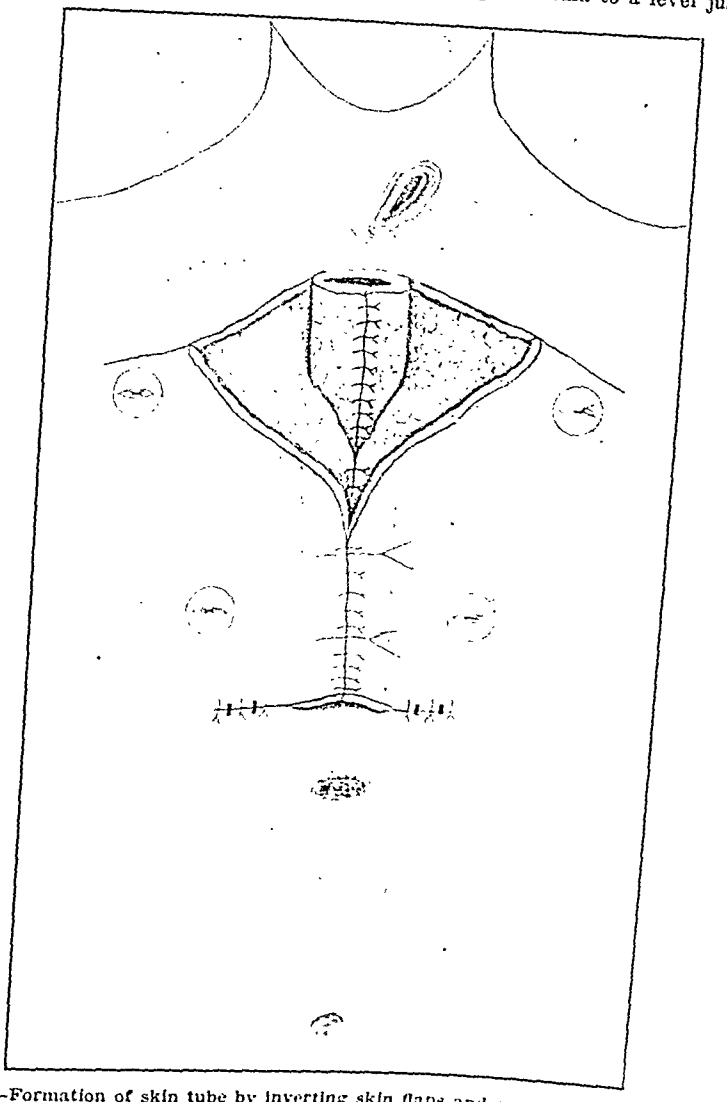


Fig. 3.—Formation of skin tube by inverting skin flaps and covering tube thus made with undermined skin flaps from each side. These were brought together by two tension sutures passing beneath skin tube and threaded on buttons on each side.

the gastric fistula. Transverse incisions were made toward the center at each end and skin and subcutaneous tissue were dissected on each side toward the center, leaving a broad base attached along the middle. The edges were brought together to form a skin-lined tube, sewing them together with one layer of interrupted fine chromic sutures going through the deeper layers of the skin and another similar layer through the subcutaneous tissue.

The skin on each side of this area was undermined and the edges were brought together over the new-formed tube by means of two tension sutures passing beneath the tube and through buttons on each side. The edges were then sutured with interrupted silk and a few silkworm-gut sutures. The transverse incisions which had been made at the ends of the vertical incisions were closed with clips and silk sutures. There was no difficulty in bringing the skin flaps over the new-formed tube. (Fig. 3.)



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done in the second stage. An anastomosis of the lower end of this tube was made directly to the upper end of the previous one by two rows of chromic sutures, none of them piercing the skin. The upper end of the new tube was sewed to the skin around the esophageal fistula, so that the latter emptied into the new esophagus.

Horizontal incisions were made laterally at the upper and lower ends of the denuded area, the skin flaps undermined, two vertical relaxing incisions made lateral to them, and the flaps brought together over the new tube with considerable tension



Fig. 5.



Fig. 6.

Fig. 5.—Artificial skin-lined esophagus completed almost down to level of gastric fistula. Tube inserted into lower end to show milk passing through.

Fig. 6.—Lower end of artificial esophagus connected to gastric fistula by means of rubber tube and patient able to drink and eat soft or well-masticated food in the normal manner.

and with some small bare areas. They were sewed together with interrupted silk sutures.

Convalescence from this stage was not as smooth as from the other stages. Due to the tension of the skin, large areas sloughed and very slowly healed by granulation. At the points of anastomosis, healing was perfect, but a fistula formed in the middle of the upper new-formed segment and discharged saliva and any fluid taken by mouth.

Patient finally left the hospital on Oct. 28 with all areas healed except this fistula ¾ inch in diameter and a bare area on chest 3 inches by 1 inch not yet covered by skin. By Feb. 15, 1939, all wounds were healed and the artificial esophagus

was intact from the mouth to its lower end just above the gastrostomy wound (Figs. 5 and 6).

However, our troubles were not yet over, for it was very difficult to fit a tube into the gastrostomy wound and the lower end of the esophagus that would not leak. Finally, a Pezzer type of tube was inserted into the stomach and held snugly by a collar pressed down on the outside of the wound and the other end was inserted into the lower esophagus without leakage. But after each meal, stomach contents regurgitated through the tube and irritated the skin in the esophagus. To correct this, a small screw clamp was placed on the rubber tube, by means of which the patient compresses the tube after each meal.

This is as far as we will proceed with this case, for it would probably be impossible to make a successful anastomosis of a skin tube with the gastrostomy wound because of the irritation of the skin from the gastric juice. Neither did we think any of the other methods mentioned in the beginning of this paper would be feasible, because of the adhesions following two gastrostomies and the irritated condition of the skin after more than ten years of a gastric fistula. Furthermore, we did not think the attempt justifiable in view of the high mortality of the other methods and the very satisfactory functioning of the present skin-rubber tube esophagus. It also makes it possible to supplement feeding through the esophagus with additional feeding directly into the stomach if necessary.

This patient is very happy with the result, and, even though she cannot swallow solid food, she has no difficulty in washing it down with fluids, after it is thoroughly masticated.

CONCLUSIONS

1. The making of an artificial extrathoracic esophagus has a very limited field; namely, (a) in cases of benign stricture that are absolutely impermeable by all known methods, and (b) in cases of malignant stricture in which the cancer has been successfully removed.

2. Where indicated, the making of an esophagostomy and a skin tube down the front of the chest is the simplest and safest method. The only disadvantage is the difficulty or impossibility of making a connection between the lower end and the gastric fistula, but this gap can be easily bridged by a short rubber tube.

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and the cecum delivered into the wound. In those animals in which no cecal appendage was present, the cecal pouch was used. A large bore cannula was tied into a puncture opening in the tip of the cecum or appendage, and the bowel wall was reflected further onto the cannula by means of a purse-string suture placed at a small distance around the first tie. A tie was placed loosely around the base of the appendage, or

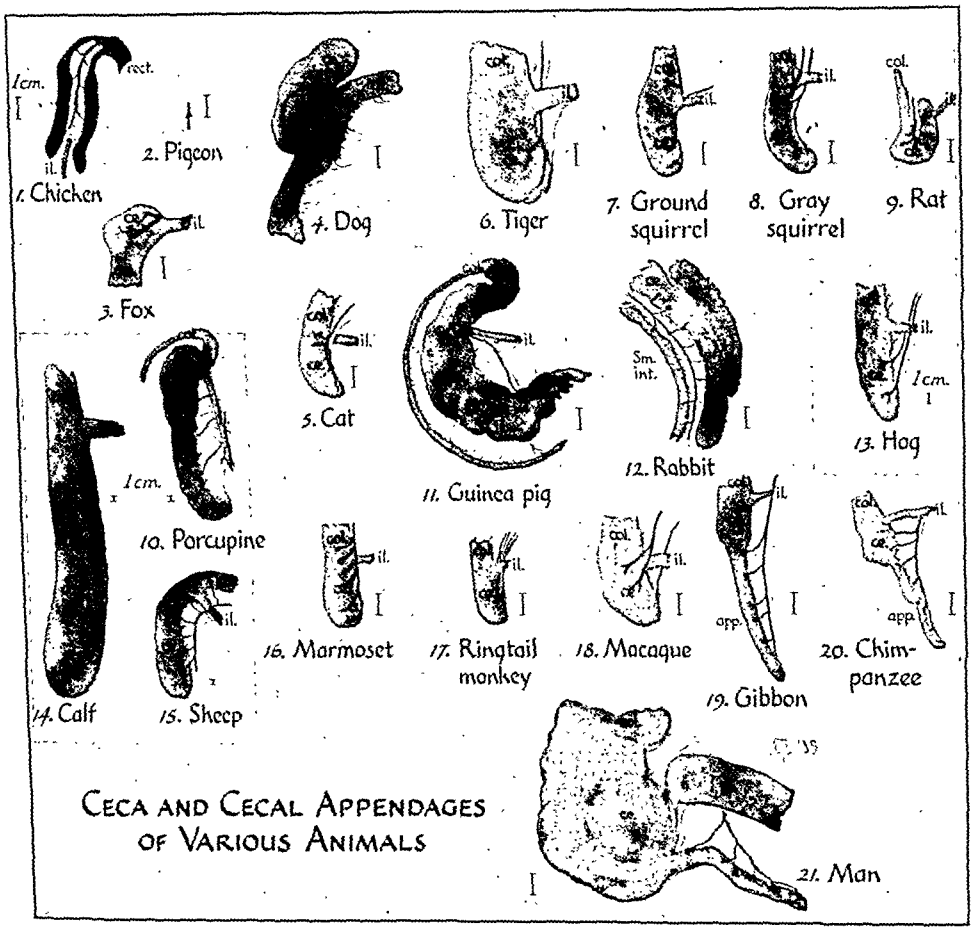


Fig. 1.—Outline drawings of the cecal appendages (or vermiform appendices) of the various animals studied. The scale of the drawings is indicated in each case by the fine vertical line beside it.

around the base of the cecal pouch in those species lacking a true appendage, and the lumen was washed with a small amount of sterile saline solution, or tap water. The loosely laid tie was now made tight, forming a closed loop of the appendage. The volume of this closed loop was determined at 10 or 20 cm. of water pressure. The abdominal wound was closed in layers with silk. In certain instances a small rubber balloon on a catheter was left in the abdomen for recording of

AN INQUIRY INTO THE FUNCTIONAL CAPACITY OF THE CECAL APPENDAGE IN REPRESENTATIVE BIRDS AND MAMMALS*

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(From the Department of Surgery of the Medical School of the University of Minnesota)

IN A PRELIMINARY report (Wangensteen, Buirge, Dennis, and Ritchie, 1937) it was observed that the cecal appendage of the rabbit and the vermiform process (or appendix) of man exhibit a greater capacity for secretion than for absorption of fluid. This suggested that the rabbit might be a satisfactory animal for the investigation of the production of acute appendicitis by obstruction of the lumen and consequent rise in intraluminal pressure. Since the cecal appendage of the rabbit differs in certain essential structural respects from the vermiform appendix of man, anatomical and physiological studies were undertaken on a variety of available animals in an effort to find a species more closely resembling man. It then came to the attention of the authors that, although extensive comparative anatomical studies of the cecal region, such as those of Huntington (1903), Kelly and Hurdon (1911), and Reider (1936), have been made, no extensive studies of the comparative physiology of this region have been made. It, therefore, seemed highly relevant to the study of the etiology of appendicitis in man to make comparative studies on the secretory and absorptive function of this region in as many animals as are available and manageable in an experimental laboratory. It is hoped that the results of such a study will perhaps suggest a clue as to the far lower frequency of acute inflammation in these lower animals than obtains in man. The comparative anatomical studies mentioned above indicate that only in man, the chimpanzee, the gibbon, the gorilla, and the orangutan is a true vermiform appendix found; very similar structures in many respects, however, are to be found in the rabbit and the wombat. Throughout this paper, the term cecal pouch is considered synonymous with the word cecum. The term cecal appendage is reserved for the blind segment springing from the cecum in those species in which such a structure is found. (Fig. 1.)

METHODS

Surgery.—Strict aseptic surgical technique was observed throughout. The type of operation used was as follows: The abdomen was opened

*The researches presented were supported by a grant from the Graduate School of the University of Minnesota and by a grant for technical assistance from the Federal Public Works Administration, Project No. 665-71-3-69, Subproject No. 258

Received for publication, September 14, 1939.

time for examination and amputation of the specimen. It was assumed that any organ which secreted a significant volume of fluid following obstruction would show noticeable changes in appearance. These experiments were used only as supplementary procedures except in the case of the pigeon, in which the pouches are too small for incannulation.

*Anesthesia.**—Amytal or pentobarbital was used for anesthesia. In the great majority of animals it was possible to inject the initial dose without preliminary medication, but with the bear, chimpanzee, tiger, etc., preliminary ether anesthesia was attained in a closed chamber after the method described by Fulton (1937).† The usual dosage of

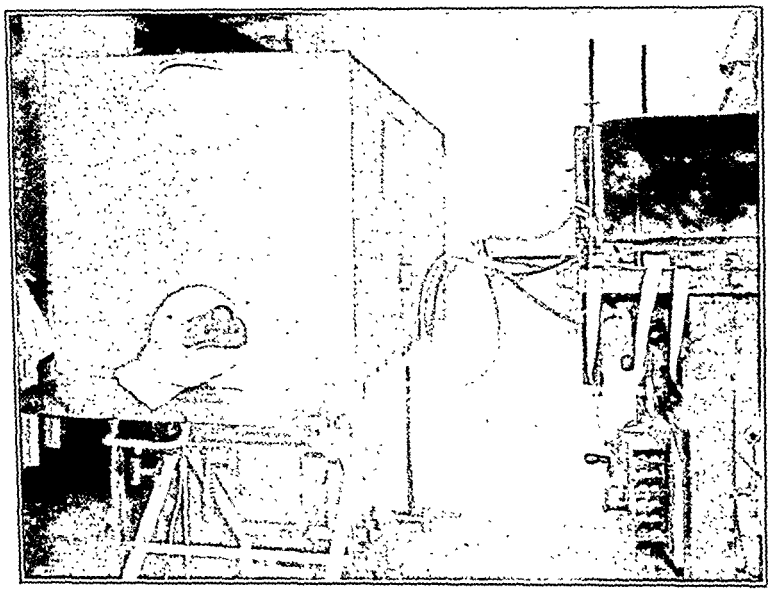


Fig. 3.—Arrangement of apparatus for the study of intraluminal pressure attending ligation of cecal appendages. The photograph shows a gibbon within a thermostatically controlled temperature box.

pentobarbital sodium was 35 mg. per kilogram of body weight; the dosage of amytal was somewhat larger.

Following the initial procedures, anesthesia was maintained at a depth just sufficient to prevent struggling. For this purpose amytal was usually injected subcutaneously by an electrically driven syringe, repeating the initial dose in the first six hours, after which the rate of injection could be slowed.

Care of the Animal While Under Anesthesia.—Except in a few of the earliest animals in which the temperature was not controlled, the rectal

*The possibility of anesthetizing animals by having them ingest meat into which pentobarbital sodium had been introduced was explored somewhat. Our experience would suggest this method as a feasible means of capturing large felines in the wild, provided the barbiturate is in shredded form and coated with phenyl salicylate.

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intra-abdominal pressure. A 7 cm. piece of rubber tubing (Dakin's tubing) from the cannula was led out through one end of the wound.

At the end of the experiment, the incision was opened and the cecum or appendage removed, the stump being inverted and the abdomen closed. Except for the sheep, calf, and tiger, the majority of the animals were saved. The freshly removed specimens were fixed in 4 per cent formaldehyde solution for microscopic study.

Recording.—Variations in the pressure within the appendage or cecum were determined by a recording mercury manometer of small bore such that the instrument plus the tubing (pressure tubing except through the wound and inside the abdomen) required the addition through the cannula of 1.1 c.c. of fluid to raise the reading 100 cm. of water* (Fig. 2). It was a simple procedure, therefore, to calculate the

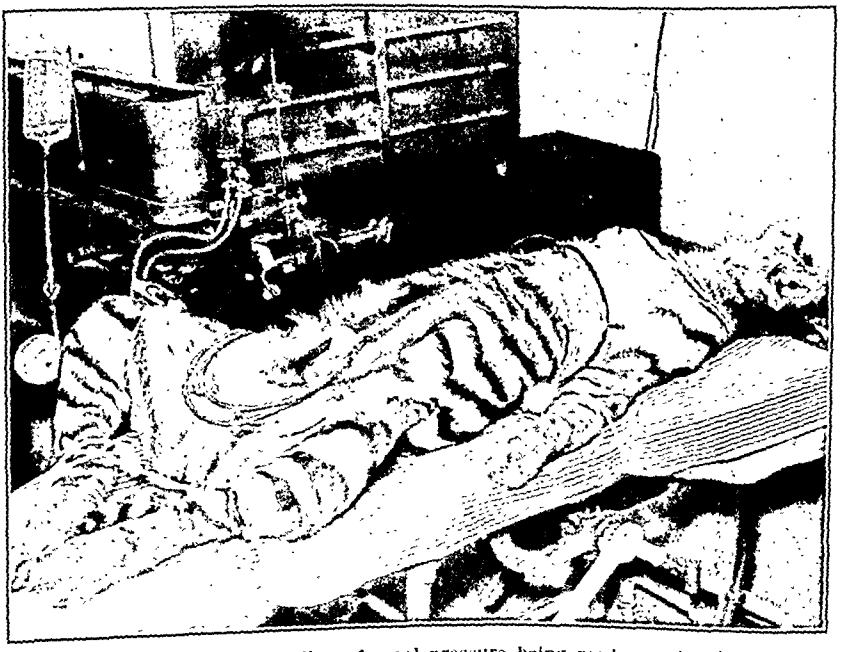


Fig. 2.—Pressure recording of cecal pressure being made on the tiger.

pressure developed in the system as well as to determine how much fluid was added by secretion or removed by absorption. No increase in fluid in the external system was considered significant unless this increase was comparable to the measured amount of fluid initially left in the lumen.

In some of the animals studied, simple ligation of the base of the cecal pouch or appendage was performed, without incannulation of the tip. The abdomen was reopened after varying specified periods of

*In the experiments on the apes, monkeys, and the tiger a new manometer was used, which required the addition of 0.54 to 0.55 c.c. of fluid to raise the pressure from 0 to 100 cm. of water.

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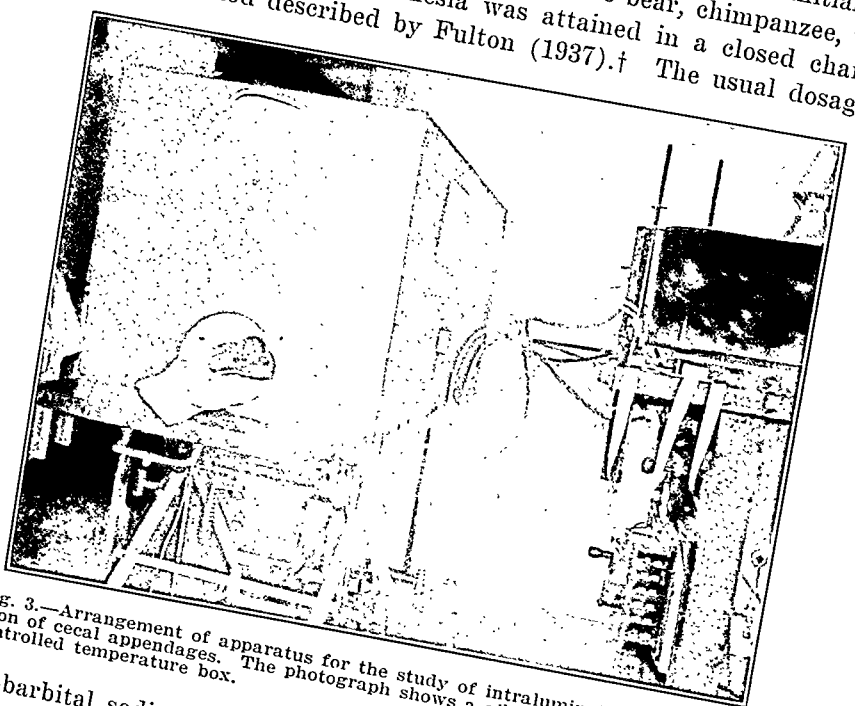


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temperature of the animal was maintained between 37 and 39° C. by the use of a thermostatically controlled chamber kept at 29° C. (85° F.) (Fig. 3).

In order to prevent the development of pulmonary congestion and subsequent pneumonia, it was found necessary not only to control the temperature, but also to turn the animal from side to side every two to four hours. In addition, subcutaneous injections of solutions of 0.9 per cent sodium chloride alternated with 5 per cent glucose in distilled water were given twice daily in amount equal to 5 to 6 per cent of the body weight. In those animals in which it was possible, urine was collected and measured, and the specific gravity determined, the administration of fluid being governed according to these findings.

FINDINGS

The findings on twenty-six species studies are presented in the order in which these species were placed for us by Mr. Gustav Swanson.*

Fowl (Class Aves).—

Duck (*Anas platyrhynchos* Linne): Three mallard ducks were used. Examination two weeks after simple ligation in two of them showed the ligated cecum to be unchanged grossly, but on microscopic examination some thickening of the wall was evident, due chiefly to thickening of the mucosa. In the other of these birds a recording was made over a period of five and one-half hours; the pressure fell to 0 from 10 cm. of water in two hours, and the cecum was demonstrated to absorb 1.4 c.c. of fluid in the five and one-half hours. Microscopically no inflammation was demonstrable.

Goose (*Anser anser* [L.] is the ancestor): Four geese were used. Examination six weeks after simple ligation in two of them showed no significant gross changes except that the ligated ceca were smaller than the controls in each bird. Microscopically there was little difference. The other two birds were used for recordings. In one of them the picture was confused by the formation of considerable gas in the lumen, but the other showed definite evidence of fluid absorption in five hours. There was no change microscopically.

Chicken *(Gallus):* Eleven chickens were used.† Ten of these were subjected to simple ligation of one of the paired ceca without washing the lumen. All but three showed at the time of examination (varying from two hours to thirty-eight days) shrinkage and thickening of the wall of the ligated cecum; in the case of the three exceptions the ceca were filled with feces, gas, and some fluid, in no case with fluid alone. These specimens showed no evidence of acute inflammation among the six which were examined microscopically, with one exception; this

*We wish to express our appreciation to Mr. Gustav Swanson, Assistant Professor of Economic Zoology, University Farm, University of Minnesota, St. Paul, Minn., for his kindness in supplying the classification of most of the species studied.

†To Dr. Benjamin Pomeroy, Instructor in Veterinary Medicine at the University of Minnesota, who helped with the experiments in the fowl, we acknowledge helpful assistance.

was a shrunken specimen, forty-eight hours after ligation, and probably due to manipulative trauma such as Wangensteen and Bowers (1937) showed could be produced in the dog. A record was run on the last chicken for two hours, and no evidence of secretion was found.

Pigeon (*Columba livia* Gmelin): Since the paired ceca of the pigeon are too small for incannulation, measuring 1 by 2 mm., both ceca of two birds were ligated with fine silk. One was sacrificed two weeks later and showed slight enlargement on both sides; the other was sacrificed seven months later, when one cecum was a mere pinpoint, and the other was twice normal diameter. Whether or not these changes might be due to increase in quantity of fluid is very questionable. Microscopic examination of the enlarged ceca showed the mucosa and lymphoid tissues thinned to two to three layers of cells. No polymorphonuclear cells were seen.

Class Mammalia, Order carnivora.—

Dog (*Canis familiaris* L.): Two of the four dogs used were subjected to simple ligation of the base of the cecal pouch. In one of these the lumen was washed prior to ligation, using an enterostomy tube inserted through the opposite wall of the large bowel. On the ninth day relaparotomy was done; there was a mass of adhesions about the cecal pouch, and the enterostomy wound was clean and well healed. The pouch was contracted, with the wall thickened, adhesions covered the serosa, and thick fluid was found in the lumen. There was no evidence of rupture. Microscopic examination showed a normal cecum except for traumatic serositis. In the other experiment in which simple ligation was done, washing was not carried out. On the tenth day relaparotomy showed a contracted cecal pouch with many adhesions, the lumen containing thick mucoid material. Again there was no evidence of rupture. Here also microscopic examination showed only a traumatic serositis. Evidently there had been no fecal matter in the cecum at the time of ligation. These findings therefore confirm those of Wangensteen and Bowers (1937), who found that ligation of a clean cecum in the dog resulted in no untoward developments (although the presence of feces in the lumen at the time of ligation resulted in the development of acute inflammation).

In the remaining two dogs recordings were made. Calculations showed that in one dog the cecum absorbed 17 c.c. of fluid in five hours, and in the other it absorbed 6 to 7 c.c. in the same time, the pressure tending to fall to about 3 to 6 cm. of water. In the first dog the pressures were maintained at about 25 cm. of water; in this case the microscopic examination showed very few polymorphonuclear leucocytes in the muscle, none in the mucosa. In the second animal the pressures were kept between the intra-abdominal level of 4 cm. and 10 cm.; here the microscopic examination showed no evidence of inflammation at all.

temperature of the animal was maintained between 37 and 39° C. by the use of a thermostatically controlled chamber kept at 29° C. (85° F.) (Fig. 3).

In order to prevent the development of pulmonary congestion and subsequent pneumonia, it was found necessary not only to control the temperature, but also to turn the animal from side to side every two to four hours. In addition, subcutaneous injections of solutions of 0.9 per cent sodium chloride alternated with 5 per cent glucose in distilled water were given twice daily in amount equal to 5 to 6 per cent of the body weight. In those animals in which it was possible, urine was collected and measured, and the specific gravity determined, the administration of fluid being governed according to these findings.

FINDINGS

The findings on twenty-six species studies are presented in the order in which these species were placed for us by Mr. Gustav Swanson.*

Fowl (Class Aves).—

Duck (*Anas platyrhynchos* Linne): Three mallard ducks were used. Examination two weeks after simple ligation in two of them showed the ligated cecum to be unchanged grossly, but on microscopic examination some thickening of the wall was evident, due chiefly to thickening of the mucosa. In the other of these birds a recording was made over a period of five and one-half hours; the pressure fell to 0 from 10 cm. of water in two hours, and the cecum was demonstrated to absorb 1.4 c.c. of fluid in the five and one-half hours. Microscopically no inflammation was demonstrable.

Goose (*Anser anser* [L.] is the ancestor): Four geese were used. Examination six weeks after simple ligation in two of them showed no significant gross changes except that the ligated ceca were smaller than the controls in each bird. Microscopically there was little difference. The other two birds were used for recordings. In one of them the picture was confused by the formation of considerable gas in the lumen, but the other showed definite evidence of fluid absorption in five hours. There was no change microscopically.

Chicken *(Gallus):* Eleven chickens were used.† Ten of these were subjected to simple ligation of one of the paired ceca without washing the lumen. All but three showed at the time of examination (varying from two hours to thirty-eight days) shrinkage and thickening of the wall of the ligated cecum; in the case of the three exceptions the ceca were filled with feces, gas, and some fluid, in no case with fluid alone. These specimens showed no evidence of acute inflammation among the six which were examined microscopically, with one exception; this

*We wish to express our appreciation to Mr. Gustav Swanson, Assistant Professor of Economic Zoology, University Farm, University of Minnesota, St. Paul, Minn., for his kindness in supplying the classification of most of the species studied.

†To Dr. Benjamin Pomeroy, Instructor in Veterinary Medicine at the University of Minnesota, who helped with the experiments in the fowl, we acknowledge helpful assistance.

of them died of spontaneous multiple intussusceptions which recurred in each case even after reduction with enemas, after suspension of the apex to the anterior abdominal wall during operative reduction, etc. Two of the skunks had more than one area of intussusception at post-mortem examination.

More recently an opportunity was offered to do post-mortem examinations on two more skunks, one adult and one 3 weeks old. These had been fed a more varied diet, containing large quantities of insects, and in neither of them was any evidence of intussusception found. The younger one had been shot with a rifle; the older had died of a pelvic abscess.

Cat (*Felis domestica* Fischer): Three cats were used. In the first of these simple ligation was performed, after unsuccessful attempts to irrigate the lumen. The cecum was removed two days later; at this time it was contracted and there was an area of necrosis in the wall opposite the mesentery. Microscopic examination showed acute inflammation. There was no evidence of secretion. Inflammation was attributed to trauma.

Records were made on the other two cats, the cannula being inserted in each case through the wall of the colon above the ileocecal valve, leakage being prevented by a purse-string suture; the cannula was led down the lumen into the cecum, the neck of which was tied tightly about a constriction near the tip. In the first cat the recording ran for eight hours; there was fermentation in the material in the cannula producing a rise in pressure recording, but the tip was found completely plugged at the end of the experiment, and the cecum was completely empty; whereas, 0.3 c.c. had been left within the lumen at the start of the experiment. In the second experiment the pressure remained at about the intraperitoneal level throughout, the lumen being empty at the end. In neither case was there microscopic evidence of inflammation except that in the first animal a small nest of polymorphonuclear leucocytes was found in one place in the muscle, presumably due to trauma.

Tiger (*Felis tigris* Linne): A senile, edentulous, failing, 182-pound tigress was offered to the authors for disposal, and recordings were made upon this animal. The cecum was found to have no tenia, and the pouch measured only 4 by 4 cm. After ligation of the base and incannulation, the volume was 2.5 c.c. The record was run for thirteen hours; the intraluminal pressure fell consistently to about minus 8 cm. of water in spite of a steadily rising intraperitoneal pressure which was recognized within four hours as being due to acute gastric dilatation. Attempts were made repeatedly to pass a gastric tube, but the cardia could not be passed; in addition the esophagus was too long for the stomach to be reached by hand. The intra-abdominal pressure terminally reached 22 cm. of water. No evidence, grossly or micro-

Red Fox* (*Vulpes fulva* [Desmarest]): Opportunity was offered to work on five red foxes. The cecal pouch of the fox is supplied with blood through vessels in a very fine veil which binds it closely to the ileum, as indicated in Fig. 1. This arrangement resulted in the loss of two foxes after attempts at simple ligation of the base of the cecum without recordings. In each of these cases there was gangrene of the whole cecum. A third attempt was successful. The cecum was re-examined thirteen days later and appeared grossly and microscopically normal.

Pressure tracings were made on the other two animals. Each of these experiments ran for seven hours, and each failed to show any evidence of fluid formation within the lumen of the cecum; one cecum was found flaccid and empty, the other almost empty, but edematous. In the first, microscopic examination showed no serosal reaction, very occasional polymorphonuclears in the musele, and intact mucosa; in the second the findings were similar, but without polymorphonuclears at all. The muscle is very thin in this species, with abundant mucosa and villi.

Raccoon (*Procyon lotor* [L.]): Two raccoons were loaned to us. Laparotomy on one of them showed the same situation as obtains in the skunk and the bear, no evidence of ileocecal valve or cecum being present. In the raccoon a thickening of the wall of the bowel was present in about the site where the ileocecal valve would be expected in many other species; this suggested a muscular sphincter. The wall of the bowel below this point was thicker than that of the ileum, and the surface was finely corrugated. No sections were taken.

Minnesota Black Bear (*Euarctos americanus* [Pallas]):† A 210-pound, 2-year-old black bear was loaned to us. Laparotomy showed the bowel to continue without interruption from jejunum to rectum, without ileocecal valve. Although there was no definite division between the ileum and the colon, on progression down the intestine, there was a definite change of color with some gradual thinning of the walls, and with some definitely visible strands of longitudinal musele below the point at which the ileocecal valve would be expected in many species.

Skunk (*Mephitis mephitis hudsonica* [Richardson]): Three skunks were presented to one of us. Their estimated ages were 2 to 3 weeks, and their weight about 500 gm. each. Laparotomy was performed on one of them and the bowel was found to be continuous from duodenum to rectum without any semblance of either ileocecal valve or cecum. All three of these animals were fed hamburger and cod-liver oil, and all three

*We wish to thank Dr. R. G. Green, Professor of Bacteriology, University of Minnesota, for placing these animals at our disposal.

†The experiments on the bear, the tiger, the marmoset, the ring-tailed monkey, two of the macaques, one of the gibbons, and the three chimpanzees were done at the Como Park Zoo of the City of St. Paul. We wish to express our gratitude to Mr. Fred M. Truax, Commissioner of Parks, Playgrounds, and Public Buildings, and to his staff for their invaluable help in the handling of these animals and for the excellent facilities provided.

time of ligation. In the other rat the tie was still present also, and the lumen was still obstructed, but a new opening had formed around the tie into the large intestine.

In the other three rats recordings were made of pressure variations. It was found that with the experiments started at 0 pressure in each case, the level rose in a short time to 7 or 8 cm. of water; removal of fluid at this point was consistently followed by a second rise in pressure, etc. The most convincing of these experiments is summarized as follows:

The initial procedures were carried out as described under "Method."

TIME (MIN.)	PRESSURE REACHED (CM. WATER)	VOLUME REMOVED (C.C.)	PRESSURE AFTER REMOVAL
0	2.5	0.4	1.0
49	5.0	0.6	1.0
93	4.0	0.6	0
126	2.0	0.2	1.0
183	4.5	0.4	0
244	5.0	0.3	-1.0
334	3.0	0.4	1.0
391	3.0	0.3	0

During this period there were waves every 20 to 40 seconds, lasting 10 seconds, rising from 2 to 7 cm., and returning approximately to the base line; these became less prominent as time passed. At the conclusion the animal was examined, and the appendage found to contain 1.8 c.c. The total amount of fluid removed was 3.2 c.c.; the sum of this and the amount in the appendage at the end minus the maximum amount which could have been present at the start (1.7 c.c.) is 3.3 c.c., the amount which must have been produced by the cecal pouch during these six and one-half hours.

Therefore the cecum of this rat secreted, or at least transferred fluid into the lumen during this experiment, although the pressure could not be so raised above 5 cm. of water. The only consistent finding microscopically was edema of the pouch wall except that one specimen showed a very few polymorphonuclear leucocytes in the wall. In this animal the pressure did not rise above 5 cm. of water. Inasmuch as a sustained pressure of 8 cm. was found sufficient by Wangensteen and Bowers (1937) to produce inflammatory changes in the cecum of the dog, the changes in this pouch in the rat might conceivably be due to this degree of sustained pressure.

Canada Porcupine (*Erethizon dorsatum* [L.]): One porcupine was obtained. A record was run for six hours. The cecal pouch was about 24 cm. long and contained about 55 c.c. of fluid and liquid stool when first exposed. The cecal pouch in this species resembles the entire cecum of the rabbit in many respects, but there is, of course, no cecal appendage. The record was started with 5 c.c. in the pouch, and 10 c.c. was added during the experiment, at the end of which the pouch contained only 1.6 gm. of material of a very thick consistency. The pressure remained around 6 to 7 cm. of water throughout the five and one-half hours; this probably was the intraperitoneal pressure. Micro-

scopically, was found of inflammation on post-mortem examination. There was considerable lymphoid tissue present.

Class Mammalia, Order Rodentia.—

Rabbit (*Oryctolagus cuniculus* [L.]): The rabbit was the first experimental animal studied from the point of view of appendical secretion. Inasmuch as a special and more complete report on the behavior of the rabbit appendage is to be made in the near future, details are omitted here. The appendage of the rabbit secretes 20 to 50 c.c. of fluid daily, and ligation at the base under varying circumstances has been found to lead to the production of all grades of acute inflammation, including gangrene and perforation.

Gray Squirrel (*Sciurus carolinensis* Gmelin): Three gray squirrels were caught and used for recordings. In all three the pressure consistently fell to about 4 cm. of water, and the calculated amounts of fluid absorbed were 2.4, 0.8, and 1.8 c.c. respectively in six, six and one-half, and five hours, respectively. (The details of calculations are illustrated in the discussion on the rat.) No evidence of inflammation was found in any of the specimens. There was very little lymphoid tissue present.

Striped Gopher (properly Ground Squirrel) (*Citellus tridecemlineatus* [Mitchill]): Four native striped gophers were caught and used. Two of them were subjected to simple ligation of the cecal pouch. One of these was found half eaten in the cage one week later; the abdomen showed no sign of inflammation and section of the appendage showed only autolysis. The surviving animal lasted until sacrificed five months later, when the cecum was found communicating with the pouch, and no sign of the suture could be found. Recordings were made with the other two animals. In one the initial volume was 0.4 c.c., and in the other it was 0.8; both were almost entirely empty six and one-half hours later when they were sacrificed; the pressure in each case had remained at 2 cm. of water throughout the experiment except for small respiratory waves and some rhythmic contractions. On microscopic examination of the pouch no lymphoid tissue was found and there were occasional polymorphonuclear leucocytes in the mucosa, which had deep folds and large vacuolated cells. There were no polymorphonuclear cells in the muscle, but there was a serosal reaction. These minimal changes were attributed to trauma.

Albino Rat (*Rattus norvegicus* [Erxleben]): Seven albino rats were used. In four of these simple ligation of the base of the cecal pouch was performed. Two of these survived for three months, and then died, unfortunately escaping post-mortem examination. Two others were examined after being sacrificed four months after ligation. In one the tie was still present, but continuity of the lumen had been established through it, evidently by thinning of the cecal wall. The pouch was enlarged, now measuring 5 cm. in length, as compared to 2 cm. at the

the second sheep a record was run for four hours; there was no rise in pressure and the cecum was entirely empty at the end of this period. In the last animal the record was started with 200 c.c. of fluid in the cecum; there were definite peristaltic waves and rhythmic contractions registered on the smoked drum, and the pressure gradually fell. Microscopic examination showed rather marked serosal reaction, but was otherwise essentially normal except for an area of hemorrhage and polymorphonuclear invasion in the basal layer of the mucosa, questionably due to trauma.

Calf (*Bos primigenius* Linne is the ancestor): One calf was used, weighing 75 pounds. The same methods of handling the animal to prevent acute dilatation of the stomach were used as have already been described for the sheep. The cecal pouch in the calf was large and had a capacity of 75 c.c. After addition of fluid to the system, the pressure consistently fell to 0 in a matter of minutes, and the total amount of fluid absorbed in five and one-half hours was 71 c.c. The cecum was removed at the end of this time and looked grossly normal, but on microscopic examination there was a heavy infiltration of all the layers of the wall with polymorphonuclear leucocytes, which it seems most rational to explain as due to difficulty encountered in keeping the cannula open, with consequent excessive manipulation of the tissue.

Class Mallalia, Order Primates.—

Marmoset (*Hapale albicollis* [Flower and Lydekker, 1891]): Records were made over a period of twenty-five hours on a 12.5-ounce marmoset monkey. There is no true appendage in this species, but the cecal pouch is 3 cm. long and about 1.5 cm. in diameter. The pressure rose to 5 cm. in the first four hours, and then slowly fell to 0, where it stayed throughout the remainder of the experiment. The pouch was almost empty at the end of the experiment. No evidence of inflammation was found grossly or microscopically at reoperation.

Ring-Tailed Brown Monkey (*Cebus capucinus* [L.]): A 5-pound ring-tailed monkey was used for recordings for forty-one hours, during which the pressure in the cecal pouch did not rise more than 5 cm. above the intraperitoneal pressure. The pouch was 2.5 cm. long and 1.3 cm. in diameter, and after ligation of the base and incannulation had a volume of 0.6 c.c. The lack of either active absorption or secretion of fluid, at least as indicated by fluid balance as determined in this experiment, is of interest because of the very rich blood supply to the cecal pouch. No evidence of inflammation was found on removal of the pouch, either grossly or microscopically. No lymphoid tissue could be found on sections.

Macaque (*Macacus rhesus* [Desmarest]): Experiments were run on four common macaque monkeys and one of the giant variety. Three of these were early experiments on animals heavily infected with tuberculosis in which the precaution of observing and recording the

scopic examination showed some hemorrhage into the mucosa, but no polymorphonuclear invasion.

Guinea Pig (*Cavia aperea* Pallas): Simple ligation of the cecal pouch was done on four guinea pigs, and they were sacrificed at intervals from two days to six weeks. The one examined in two days showed the cecum swelled to four times normal size and contained gas and fluid in about equal volumes; microscopic examination showed no inflammatory changes. Those allowed to remain for longer periods showed no microscopic reaction; in two of them, however, the lumen had become re-established around the ligature.

Pressure recording was made on two animals. The cecum of the guinea pig is about 15 cm. long, and the stomas of the ileum and of the colon are slightly separated. In the first animal the distal half only was isolated for study; in the second the entire cecum was used by dividing both colon and ileum near the cecum, and inserting the cannula through the lumen of the colon. In the first animal the pressure remained at the intraperitoneal level and at least half the isotonic sodium chloride solution left at the start was absorbed in four hours, there being only 2 gm. of thick fecal material present at the end. In the second animal sodium chloride solution also was definitely absorbed in two hours. In neither case was there microscopic evidence of inflammation.

Class Mammalia, Order Artiodactyla.—

Common Hog (*Sus scrofa* Linne): Experiments were performed on three young hogs weighing about 50 pounds each. Examination of one of these twelve days after simple ligation showed the pouch only loosely distended with gas and fluid, and microscopically normal.

In the other two hogs records were made for five and one-half and ten hours respectively. Both experiments showed absorption in excess of 25 c.c. per four hours. Microscopic examination in the first of these two ceca showed no change; in the second there was a moderate serosal reaction (trauma).

Sheep (*Ovis aries* Linne): Four sheep were used; all of them ultimately died from pneumonia despite precautions, except for the first which died of acute dilatation of the stomach incident to tying it down on its back. In the remainder of the animals, therefore, it was found necessary to tie the animal on the table on the chest, with the four legs extending off the edges, except that a sandbag was placed under the right groin. Even in this position, dilatation of the stomach occurred so rapidly that suction applied to an inlying large stomach tube was necessary to prevent gastric dilatation. In the first of the three animals from which any information was obtained, simple ligation was performed through a flank incision. The animal died a week later, and unfortunately was not examined until the following morning when the cecum was filled with gas, but contained no fluid. In

intraperitoneal pressure by means of a balloon left in the abdomen was not taken, and the misleading impression was gained that the cecum secreted up to a pressure of 12 cm. of water in eight hours or less. Because of recognition of these faults in technique and because of the short interval of time over which these recordings were made, two experiments were run at a later date with the necessary precautions. Each of these recordings extended over a forty-seven-hour period, and in each of them the intraluminal pressure fell to from minus 2 to plus 2 cm. of water, while the intraperitoneal pressure remained in the range from plus 8 to plus 12 cm. of water. In each case the cecum was found entirely empty at the conclusion of the recording. In one case the intraluminal pressure was never more than 1 cm. above

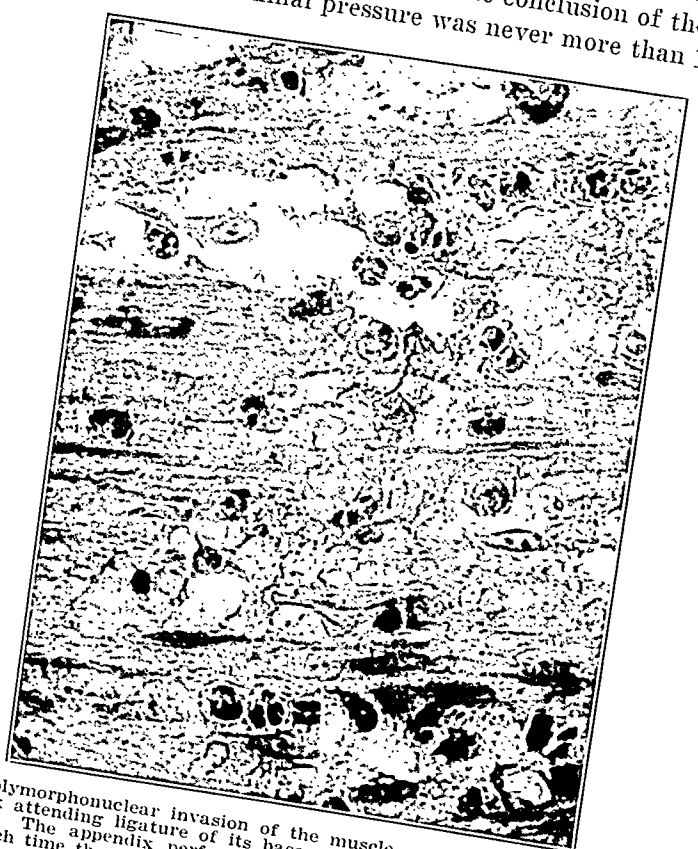
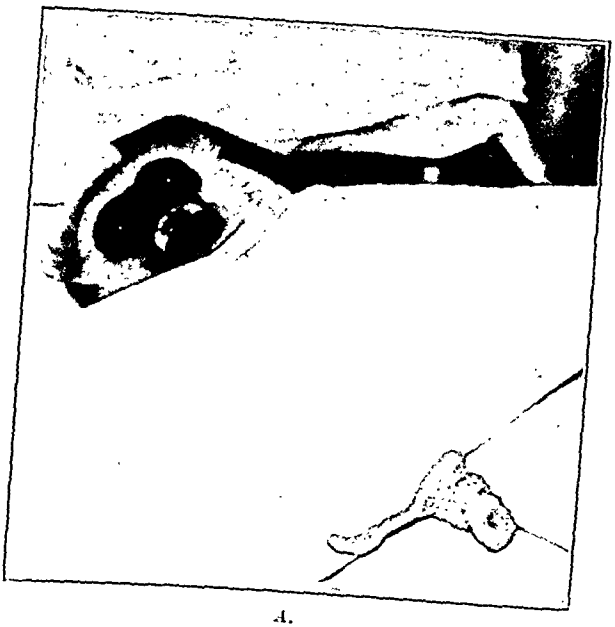


Fig. 5.—Polymorphonuclear invasion of the muscle wall of the chimpanzee vermiform appendix attending ligature of its base. The highest pressure reached was 106 cm. of water. The appendix perforated thirty-nine hours after the recording was begun, at which time the appendix was removed (magnification ×550).

the intraperitoneal; in the other it was higher by 9 cm. at nine hours, and remained below thereafter. In all probability this preliminary rise contributed to the erroneous deduction following the first three experiments. Microscopic examination showed plentiful lymphoid tissue, and in one specimen an occasional polymorphonuclear leucocyte.

Howling Golden Gibbon (*Hylobates entelloides* [Flower and Lydekker, 1891]): In two gibbons it was found that initially sufficient fluid



A.



B.

Fig. 4.—A, Photograph of the cecum and vermiform appendix of the gibbon taken at laparotomy. B, Photomicrograph (magnification ×65) of the appendix of the gibbon twenty-two hours after ligature. The highest pressure attained was 19 cm. of water and it was sustained for a short time only. There is no evidence of leucocytic invasion of the walls. Histologically the appendix may be described as normal save for serositis due to trauma.

which these appendices are attached are traditionally considered fluid-absorbing areas. In no case in the cecum itself as studied in the present experiments was secretion found to be significantly in excess of absorption. In only one animal with a cecal appendage was the cecum also investigated, the rabbit; here active absorption was observed, as will be reported elsewhere (Dennis, Buirge, Varco, and Wangensteen, 1940).

No regular relation was found between the amount of lymphoid tissue and the amount of secretion in the diverse species. In the tissues studied, it was found that gross and microscopic evidence of acute inflammation could be produced either by increase in pressure and distention (Bowers, 1937) or by trauma due to rough handling of the tissue.

A summary of the findings in this study is most conveniently given in Table I.

TABLE I

ANIMAL	CECUM PRESENT	CECAL APPENDAGE	SECRETION*
Duck	Yes	No	-
Goose	Yes	No	-
Chicken	Yes	No	-
Pigeon	Yes	No	?†
Dog	Yes	No	-
Fox	Yes	No	-
Raccoon	No	No	
Bear	No	No	
Skunk	No	No	
Cat	Yes	No	-
Tiger	Yes	No	-
Rabbit	Yes	Yes	+
Squirrel	Yes	No	-
Ground squirrel	Yes	No	-
Rat	Yes	No	Very slight
Porcupine	Yes	No	-
Hog	Yes	No	-
Sheep	Yes	No	-
Calf	Yes	No	-
Marmoset	Yes	No	-
Ring-tailed monkey	Yes	No	-
Macaque	Yes	No	-
Gibbon	Yes	Yes	-
Chimpanzee	Yes	Yes	+
Man	Yes	Yes	+

*-, Absent; +, present.

†The functional capacity of the cecum of the pigeon was not thoroughly explored because the ceca are too small for incannulation.

CONCLUSION

Among the group of animals studied, the only ones suitable for the study of the etiology of acute appendicitis from the point of view of the

appeared in the lumen to raise the pressure to 19 cm. of water, but the rise in each case was transitory, falling in a few hours to the intraperitoneal level and remaining there. Microscopic sections made at the conclusion of these experiments were normal (Fig. 4). A more detailed account is being reported elsewhere (Wangensteen and Dennis, 1940).

Chimpanzee (*Pan [Anthropopithecus] troglodytes* [Gm.]): Records were made upon three chimpanzees, and it was found that the appendix in this species secretes fluid to pressures in excess of 100 cm. of water, and that the microscopic picture of acute appendicitis can be produced in this fashion, together with rupture of the appendix (Fig. 5). The details of these experiments are omitted here because they are being reported elsewhere (Wangensteen and Dennis, 1940).

Man (*Homo sapiens* Linne): Opportunity has presented itself in several instances of patients with cancer of the large bowel to carry out much the same procedure as was used in the apes. These findings will not be reported here as they are being dealt with at length in a separate paper (Wangensteen and Dennis, 1939). Suffice it to say that the appendix of man was found to secrete in the majority of cases from 1 to 3 c.c. of fluid daily, and that this organ is capable of building up a pressure sometimes as high as 90 per cent of the systolic blood pressure, with resultant clinical and microscopic signs of acute appendicitis, with immediate remission upon releasing the pressure.

SUMMARY

Experiments have been reported with reference to the functional behavior of the cecal appendage, or cecum in those species in which there is no cecal appendage, on the duck, the goose, the chicken, the pigeon, the dog, the fox, the raccoon, the bear, the skunk, the cat, the tiger, the rabbit, the squirrel, the ground squirrel, the rat, the porcupine, the guinea pig, the hog, the sheep, the calf, the marmoset, the ring-tailed monkey, the macaque, the gibbon, the chimpanzee, and finally man. A comparative study has been made of the function of the cecal pouch or cecal appendage as regards the balance in favor of secretion or of absorption of fluid. In this group of animals only man, the rabbit, and the chimpanzee showed positive evidence of fluid production in the cecal region; in the rat there was a rather delicate balance between absorption and secretion, the pressure being raised only 1 to 2 cm. of water above the intra-abdominal pressure, and not high enough to produce evidences of inflammation.

As shown in Table I, the only animals found to bear a definite fluid secreting area capable of raising intraluminal pressures to any degree were those with a cecal appendage, or appendix, arising from the cecum proper, and distinct from it, and it was this appendix which was found to secrete fluid in excess of absorption. In one animal with an appendix, the gibbon, no such secretion was found. The ceca to

which these appendices are attached are traditionally considered fluid-absorbing areas. In no case in the cecum itself as studied in the present experiments was secretion found to be significantly in excess of absorption. In only one animal with a cecal appendage was the cecum also investigated, the rabbit; here active absorption was observed, as will be reported elsewhere (Dennis, Buirge, Varco, and Wangensteen, 1940).

No regular relation was found between the amount of lymphoid tissue and the amount of secretion in the diverse species. In the tissues studied, it was found that gross and microscopic evidence of acute inflammation could be produced either by increase in pressure and distention (Bowers, 1937) or by trauma due to rough handling of the tissue.

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Cat	Yes	No	-
Tiger	Yes	No	-
Rabbit	Yes	Yes	+
Squirrel	Yes	No	-
Ground squirrel	Yes	No	-
Rat	Yes	No	Very slight
Porcupine	Yes	No	-
Hog	Yes	No	-
Sheep	Yes	No	-
Calf	Yes	No	-
Marmoset	Yes	No	-
Ring-tailed monkey	Yes	No	-
Macaque	Yes	No	-
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*-, Absent; +, present.

†The functional capacity of the cecum of the pigeon was not thoroughly explored because the ceca are too small for incannulation.

CONCLUSION

Among the group of animals studied, the only ones suitable for the study of the etiology of acute appendicitis from the point of view of the

obstructive mechanism are the rabbit, the chimpanzee, and man himself. With the exception of certain cases in which excessive trauma was involved, microscopic evidence of acute inflammation of the organ studied failed to occur except in the presence of increase in intraluminal pressure, and hence it is again suggested that increase in pressure, secondary (in clinical cases in man) to obstruction of the lumen, is probably an important factor in the production of acute appendicitis.

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RENAL VENIPUNCTURE: A METHOD OF EXPLANTATION OF THE KIDNEY FOR VENIPUNCTURE IN DOGS

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METHODS of subcutaneously explanting the kidneys in dogs to allow repeated renal venipuncture in the intact, unanesthetized subject have been described by Rhoads (1934), Sheehan (1936), and Gorden, Alving, Kretzschmar, and Alpert (1937). The methods adopted by Sheehan and by Gorden, Alving, Kretzschmar, and Alpert differ from that of Rhoads in that they aim at isolation of the renal vein in a skin bridge to prevent contamination of the renal venous sample by accidental puncture of the renal artery or ureter. Priority in renal explantation is claimed by Allen who refers to an introductory paper (1925) in which he mentions: "The transplantation of kidneys under the skin in a manner which has long been familiar with portions of the pancreas has proved valuable; the kidneys function satisfactorily in the new location, and all sorts of manipulation and the removal of portions for microscopic study are thus readily performed without important disturbance."

The method here described is relatively simple to perform, the wound heals rapidly, and puncture of the renal vein is not difficult, as the approximate position of the vein is indicated by the single line of scar. The operative wound has no complex lines of tension and wound necrosis has never occurred. The resultant absence of massive tender scar permits venous sampling without injury or contamination. It has therefore not been found necessary to isolate the renal vein.

Animals thus prepared may be used for the determination of renal blood flow or oxygen consumption (Van Slyke, Rhoads, Hiller and Alving, 1934) or in problems of altered renal hemodynamics (Corcoran and Page, 1939) or metabolism.

METHOD

The animals chosen were mongrel dogs of 12 to 16 kg. body weight. Docile dogs of the hound type with long, lean flanks were preferred.

Under amytal (iso-amyl ethyl barbituric acid, Lilly) anesthesia, an incision was made parallel and 5 cm. from the spine, beginning 3 cm. below the last rib. The abdominal muscles were split and the kidney delivered through the opening. The hilus and vessels were then freed of fat. A pocket was made caudally under the skin into which the kidney was then inserted. Two silk stay sutures were placed between

Received for publication, August 2, 1939.

the abdominal muscles and the tough subcutaneous tissue to fasten the kidney with its upper pole at right angles to the spine.

A gutter was prepared for the renal vessels and ureter by suturing the abdominal muscles flush to the subcutaneous tissues of one edge of the wound (Fig. 1). The muscles of the opposite side were sutured to the subcutaneous tissue about 3 cm. from the edge of the wound, leaving the skin flap free to cover the open trough. The renal vessels and ureter should lie freely within this groove with the kidney in position. The renal vein should be uppermost.

The skin over the kidney was then closed by a subcutaneous stitch which did not include the gutter (Fig. 1). The skin edges were then closed by continuous fine silk suture. A large cotton dressing was applied and held in place with collodion and bandage.

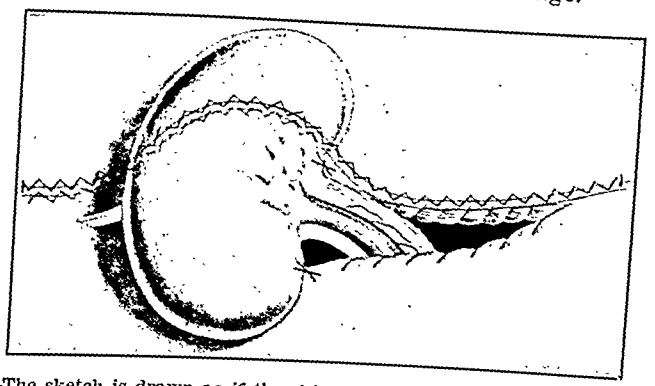


Fig. 1.—The sketch is drawn as if the skin were transparent. The line of cutaneous suture indicates the position of the skin edges. The muscular trough and the suture lines which form it are shown. The usual relative positions of renal vein, artery, and ureter are indicated, the renal vein being central and overlying the artery below and ureter above.

The dressing is taken off on the third or fourth day after operation and the continuous silk skin suture removed on the following day. Should there be evidence of wound infection or delayed healing, the sutures are removed and the wound dressed with cod liver oil, applied liberally to a large cotton dressing daily for three or four days.

A note and sketch are made at operation of the presence of anomalous positions of the renal vessels or ureter. The position of the most accessible portion of the vein is recorded with reference to the line of cutaneous suture. This position is confirmed by venipuncture when the wound has healed. It may then be indicated by the injection of a drop of India ink intradermally over the site.

SUMMARY

A method of subcutaneously explanting the kidney in dogs to render the renal vein accessible to venipuncture is described. It consists essentially in fashioning a subcutaneous muscular gutter in which renal vessels and ureter lie freely. The position of the renal vein is indi-

cated by reference to the single line of scar. The operation has the advantages that it is relatively easy to perform and that, with reasonable care, no failures occur.

The writers wish to thank Mr. R. J. Parker for technical assistance and to express their gratitude to the John and Mary R. Markle Foundation for financial assistance.

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COMPLETE RECOVERY FROM SERIOUS VASCULAR IMPAIRMENT FOLLOWING REMOVAL OF CERVICAL RIB*

SAMUEL SILBERT, M.D., NEW YORK, N. Y.
(From the Mount Sinai Hospital)

SYMPTOMS in the upper extremities due to pressure of a cervical rib are either neurologic or vascular in nature. Instances of serious vascular disturbance due to such an abnormality are relatively unusual.[1-3] The following case is of interest not only because of the marked vascular impairment, but also because of the complete anatomical and functional recovery which took place after operation was performed.

CASE REPORT

The patient, a married white woman, 38 years of age, was referred to me on Nov. 25, 1938. For one month previous to her admission to the hospital she had been complaining of pain in the left upper extremity. Whenever she raised her left arm to comb her hair or put on a dress, she precipitated an attack of pain. This was regarded as due to a neuralgia and was treated with codeine and aspirin. Two days before admission her pain suddenly became much more severe and she developed a sensation of numbness in the left hand. Her past history was entirely negative except for an appendectomy many years ago. She did not use tobacco.

The patient was a well-nourished, middle-aged woman whose general physical examination was essentially negative. In the left supraclavicular space a bony prominence could be felt which suggested a cervical rib. The pulsation of the subclavian artery was prominent over it. There was a good pulsation in the left axillary artery but no pulsation in the left brachial, radial, and ulnar arteries. The circulation in the right upper and both lower extremities was normal. The left forearm and hand were much colder than the right. The oscillometer readings in the upper extremities were as follows:

	LEFT	RIGHT
Upper arm	Faint	6
Forearm	0	5½

She was referred to the Mount Sinai Hospital and was admitted to the Surgical Service of Dr. John H. Garlock. There temperature studies revealed that the fingers of the left hand were about 7° C. lower than the right. The left axillary pulsation could no longer be felt. No motor or sensory disturbances were noted in the left upper extremity. The blood pressure in the right arm was 126/84. In the left arm the blood pressure could not be obtained. The Wassermann test was negative.

X-ray examination of the cervical spine showed a long transverse process of the seventh cervical vertebra on the right side. On the left side there was a cervical rib composed of at least three segments which articulated with each other.

Received for publication, September 11, 1939.

On Dec. 1, 1938, operation for removal of the left cervical rib was done by Dr. John H. Garlock. Avertin, ethylene, and ether anesthesia was used. The operative procedure is described by Dr. Garlock as follows:

"Transverse incision, 6 inches in length, 1 inch above clavicle. Platysma incised. Sternomastoid muscle retracted medially. Incision deepened exposing the anterior scalene muscle. The phrenic nerve was found running on its anterior surface above, extending downwards and going behind the scalene muscle and cervical rib. The muscle was attached to the cervical rib and by another prolongation to the first rib.

"The tendinous insertion in both ribs was divided, exposing the cervical rib. Considerable retraction was necessary in order to expose this structure adequately for removal. The lower cords of the brachial plexus were retracted medially and downwards. The transverse scapular artery was visible and found to be three to four times normal size, pointing toward an adequate collateral circulation. The subclavian artery was felt pulsating mesial to the position of the rib and apparently ran between the cervical rib and the first rib. The dissection was long and difficult. The rib was finally removed close to its attachment to the spine and traced downwards and outwards to a bulbous enlargement which marked the joint space visible in the x-ray. Beyond this space was another ¾ inch of rib which was united to the upper aspect of the first rib by bony union. The entire rib was removed. It was difficult to determine whether pulsation was present distal to the previous position of the cervical rib. Because of ooze from the side of the vertebral column, a piece of packing was inserted and the wound was closed in layers."

The wound healed by primary union. The patient was out of bed on the sixth postoperative day and was discharged from the hospital on the thirteenth postoperative day. On Dec. 6 oscillometer readings were repeated and showed the following:

	LEFT	RIGHT
Lower arm	0	2½
Upper forearm	0	4

On Dec. 7, one week after operation, Dr. Garlock noted that there was no evidence of pulsation at the left wrist. Skin temperature readings were repeated on Dec. 12 and showed considerable improvement in the temperature of the left hand. The comparative readings were as follows:

	11/28		12/12	
	LEFT	RIGHT	LEFT	RIGHT
Forearm	31.8° C.	34.0	31.0	32.6
Wrist	30.0	34.6	31.8	32.6
Back of hand	30.6	34.2	32.2	33.6
Tip of middle finger	27.6	34.6	31.0	32.6

On Jan. 19 the patient reported that she had had no pain since operation. No pulsation was felt in the left hand. The hand was warm, showed good color and prompt return of circulation after compression of the nail beds. On Feb. 16 the left radial pulse was felt for the first time and it was noted that the left hand was only slightly colder than the right. On April 20 patient was symptom free. The radial pulse could now be easily felt on the left. The two upper extremities were symmetrical in appearance and function was normal.

On May 12, 1939, examination showed the left brachial, radial, and ulnar pulses open. The pulses on the left side were slightly smaller than on the right. Both hands are equally warm. The oscillometer readings were:

	LEFT	RIGHT
Wrist	2½	3

The patient was symptom free. She had made a complete anatomical and functional recovery.

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X-ray examination of the cervical spine showed a long transverse process of the seventh cervical vertebra on the right side. On the left side there was a cervical rib composed of at least three segments which articulated with each other.

Received for publication, September 11, 1939.

pletely thrombosed artery may have taken place, it is possible that release of spasm was the more important factor in the recovery. Prompt recognition of the cause of this patient's symptoms, and early surgical intervention before organized thrombotic occlusion had time to develop, may therefore be responsible for the excellent therapeutic result.

Naffziger[3] pointed out that patients may have all the symptoms of cervical rib even though no such abnormality is present. Since then considerable attention has been drawn to the so-called scalenus anticus syndrome. The subclavian artery and brachial plexus pass through the neck behind the scalenus anticus muscle. When this muscle is tense, symptoms develop which are similar to those produced by a cervical rib. These are completely relieved by section of the scalenus anticus muscle, which allows the artery and plexus to be displaced forward.

SUMMARY

A case of advanced vascular impairment in the upper extremity secondary to cervical rib is presented.

Complete anatomical and functional recovery followed prompt recognition of the cause of this patient's symptoms and early surgical intervention.

The mechanism which produces the vascular impairment associated with cervical rib is discussed.

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COMMENT

Opinion is divided as to the cause of the vascular disturbances produced in the upper extremities by cervical ribs. At first it was generally believed that direct pressure of the rib upon the subclavian artery caused obstruction to the vessel at that point. However, Telford and Stopford[4] reported three instances of cervical rib with vascular impairment in which the axillary artery could be felt pulsating, and the site of obstruction appeared to be the brachial artery. They pointed out that the vascular occlusion ended abruptly in the region of the lower border of the insertion of the pectoralis major muscle. At operation they could find no evidence in any of their three cases that the subclavian artery was being constricted by pressure from the cervical rib or adjacent structures.

If pressure of the cervical rib on the subclavian artery is responsible for the vascular impairment, how is one to explain the pulsation in the axillary artery? Telford and Stopford offered the following explanation: The sympathetic nerve fibers which innervate the brachial artery and its branches sometimes form a compact band lying on the inferior surface of the inner cord of the brachial plexus. They pass into the arm with the major nerves and are given off at succeeding levels to the large arterial trunks. Constant irritation of these fibers as they pass over a cervical or high first rib results in recurring spasms of the brachial artery which finally result in thrombosis of this vessel. The sympathetic innervation of the subclavian and axillary artery is derived directly from the sympathetic chain, the fibers extending out to the arm as a perivascular plexus. For this reason this portion of the artery is not affected.

Blair, Davies, and McKissock[5] describe a case of cervical rib in which pulsation in the axillary artery was normal and occlusion was present in the brachial. At operation the subclavian artery was found to be free of any constriction or pressure by the cervical rib. This patient died ten days after operation of a pulmonary condition and it was possible to examine the brachial plexus from end to end by serial sections. The lower trunk of the plexus and the first dorsal nerve showed histologic evidence of proliferation of endoneurium and endoneurial nuclei where these nerve structures came into relation with the cervical rib. The authors regarded this as evidence of irritation of these nerve structures by the rib. They agreed with Telford and Stopford that sympathetic irritation produced in this manner was responsible for the clinical picture.

In the present case pulsation in the left axillary artery was easily felt when the patient was first seen, but this disappeared shortly after admission to the hospital. Anatomical recovery was complete and occurred in a relatively short time. While recanalization of a com-

found symptoms, and, after the second rupture, although the diagnosis was seriously suspected, no surgery could be instituted because of the patient's extremely poor condition.

CASE HISTORY

The patient, a male, aged 36 years, was first seen on April 7, 1938, complaining of sharp, knifelike pain in the upper right abdomen, radiating to the back and associated with some nausea but no vomiting. This was his first acute attack, although for several months previously he had experienced mild recurrent epigastric pains and a selective dyspepsia.

He was not seen again until Aug. 21, 1938, when he experienced another acute attack. In the intervening five months he had had no distress and had been under the observation of another physician who had carried out x-ray studies of the gall bladder which showed some filling defects suggestive of but not conclusive for cholelithiasis. While dressing on the morning of Aug. 22, he suddenly experienced a severe, persistent, knifelike pain in the upper abdomen associated with profuse perspiration and marked nausea. Examination shortly afterward revealed marked tenderness and rigidity over the entire right abdomen. Relief was obtained with morphine and atropine, but one hour later the severe pain recurred, this time mainly in the right shoulder and right lower abdomen. Examination at this time revealed marked tenderness and rigidity over McBurney's area.

Suspecting the possibility of simultaneous pathology in the gall bladder and appendix, the patient was hospitalized and surgical consultation obtained. On admission the temperature was 101° F. (rectally); pulse, 130; and blood pressure, 120/80. The next day the patient began to cough and examination revealed sibilant and sonorous râles throughout both lungs and dullness with distant voice and breath sounds at the right pulmonary base. A diagnosis of acute tracheobronchitis with right lower lung atelectasis was made and confirmed with portable roentgenograms. The abdomen was slightly distended, still markedly tender but less rigid. Temperature, pulse, respiration were 100°, 138, and 38, respectively; and the white count was 22,500 with 70 per cent polymorphonuclear leucocytes. In addition to the persistent shoulder pain, he complained of pain in the bladder region, particularly on voiding.

Because of the persistent, uncontrollable pain and increasing distention which failed to respond to Wangensteen suction, it was decided to operate. On opening the peritoneum, free bile escaped and about 500 c.c. were aspirated from the peritoneal cavity. The gall bladder was found ruptured at the fundus and 126 stones were scooped out from the gall bladder and the surrounding area. The entire bowel was markedly distended and injected. The gall bladder apparently had ruptured eighteen hours after the onset of the biliary colic, resulting in bile peritonitis and paralytic ileus. A tube was sewed into the gall bladder and the peritoneum was closed. The postoperative course was stormy. The ileus was controlled by constant suction, and a subsequent bilateral bronchopneumonia and severe phlebitis of the left leg were overcome.

The patient was discharged on Sept. 10, 1938, in fairly good physical condition except for a draining biliary fistula, through which he subsequently passed several small stones. Several weeks later he developed a large hernia at the operative site, but nevertheless, he was able to return to his work. On Nov. 29, 1938, lipiodol was injected into the fistulous tract and roentgenograms were taken with the patient in the prone position. These clearly outlined the sinus communicating with the gall bladder, the two main and several collateral divisions of the hepatic duct, the cystic duct and the common duct with its entrance into

ACUTE FREE PERFORATION OF THE GALL BLADDER OCCURRING TWICE IN THE SAME PATIENT

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PERFORATION of the gall bladder is more common than is generally appreciated. Three types are recognized: chronic perforation with presence of a fistulous communication between the gall bladder and some other viscus; subacute perforation, in which the perforation is surrounded by an abscess walled off by adhesions from the general peritoneal cavity; and acute perforation into the free peritoneal cavity.

A review of the literature shows that this third type, designated as "acute free perforation," is uncommon, is rarely diagnosed preoperatively, and carries a high mortality. McWilliams[1] collected 108 cases from the literature and in his own series of 3,180 gall-bladder cases found 29 perforations, of which 6 were acute. Gosset[2] reported 111 cases with a mortality of 52 per cent. Georg[3] recorded 348 cases found in the literature prior to 1925 with a mortality of 42 per cent. Fifield[4] found 27 cases of perforation in a total series of 1,066 gall-bladder cases, with a mortality of 44 per cent, but, of these, only 17 were acute free perforations. Alexander[5] cited 1,000 cases of biliary disease with 20 perforations, of which only 8 were acute, with a mortality of 50 per cent. Mitchell[6] reported 16 perforations in 1,270 gall-bladder operations with a 50 per cent mortality, including 6 cases of acute free perforation. During a ten-year period at the Mayo Clinic, Judd and Phillips[7] recorded 61 cases of perforation, in only 2 of which were there extravasations of contents into the general peritoneal cavity. Of 349 operations reviewed by Niemeier,[8] 8 perforations were encountered, but only 2 were of the free acute type; and Larson[9] found 12 cases in 706 operations with a mortality of 50 per cent.

Such statistical considerations indicate that perforation of the gall bladder is not rare, occurring as it does in approximately 1 to 3 per cent of gall-bladder cases. If these statistics are further analyzed, it becomes apparent that acute free perforations into the general peritoneal cavity occur in less than 1 per cent of all gall-bladder cases. While the incidence of such occurrence is remarkably small, the important consideration is that it does occur and should consequently be considered when treating gall-bladder patients.

Perforation of the gall bladder twice in the same patient is an extremely rare occurrence. A careful review of the literature reveals only one such report, that of Fisher and Mensing in 1926.[10] It is because of its rarity that we wish to record the second case. With both perforations bile escaped into the free peritoneal cavity causing pro-

Received for publication, September 5, 1939.

The gall bladder was small with thickened walls and contained eight faceted stones. Through an opening in the fundus (8 mm.) at the lower margin of the liver, bile had apparently escaped (Fig. 2). The mucosa was atrophic throughout and adjacent to the perforation showed polygonal depressions forming a negative for two stones. The stones at the neck of the gall bladder protruded into the proximal portion of the cystic duct, which measured up to 10 mm. The common duct was patent. The adjacent liver surface showed hemorrhagic areas extending into the parenchyma. The fistula, beginning at the perforation in the fundus, was 3 cm. long, ending in a scar, beyond which it passed to the abdominal wall.

The heart showed evidence of eccentric hypertrophy and acute parenchymatous degeneration; the lungs showed acute passive congestion with hemorrhages; and the spleen, acute septic swelling. Bacteriologic examination of the peritoneal fluid demonstrated the presence of *B. coli* and *B. welchii*.

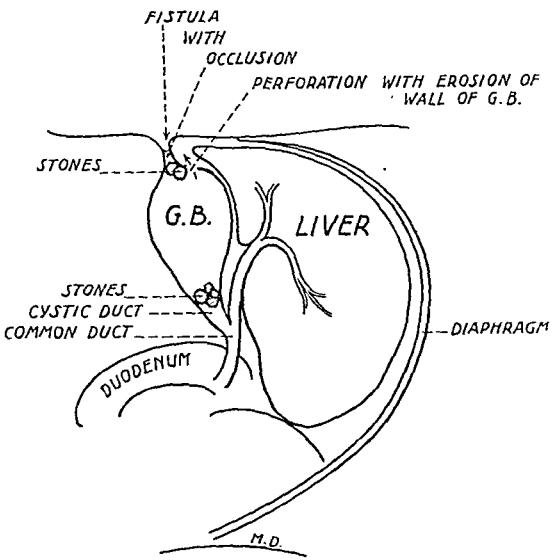


Fig. 2.—Semidiagrammatic sketch of the condition found at autopsy.

Histologic study of various tissues showed acute fibrinous diaphragmitis, chronic cholangitis, and acute fibrinous perihepatitis with multiple liver hemorrhages and nodular hyperplasia, chronic cholecystitis, acute nephrosis with acute passive congestion of the kidneys, hemorrhages in the gastric mucosa, multiple pulmonary hemorrhages, and acute fibrinous peritonitis.

The cause of death was an acute biliary peritonitis.

COMMENT

This unusual case demonstrates many points of interest. In both instances perforation apparently occurred within twenty hours of onset of the acute biliary colic. So short a time element is very unusual. In most instances fortunately perforations are not fulminating events. Theoretically at least, there is an excellent protection given the gall bladder by its surrounding anatomical structures; the parietal peritoneum, the undersurface of the liver, the transverse colon, and the omentum all tend to prevent infection from spreading, limiting the resulting peritonitis. In the series of cases reviewed by Judd and

the duodenum (Fig. 1). The fistula stopped draining and closed completely on Jan. 5, 1939. In the interim efforts to reduce the patient, who was obese, were made with advice to have the diseased gall bladder removed.

The patient was entirely symptom free until Jan. 24, at which time he experienced some mild pains in the right upper quadrant which spontaneously subsided within several hours. However, that night the abdominal pain recurred in a severe form with nausea and pain in the right shoulder. Between 9:00 and 11:00 P.M., 1¼ gr. of morphine in divided doses were administered with only slight relief and the patient was again hospitalized. Admission temperature was 101° F.; pulse, 95; respiration, 35; and white cell count, 22,800. The entire abdomen was tender, but rigidity was difficult to determine because of the large hernial



Fig. 1.—Lipiodol injected into the fistulous tract outlining the sinus communicating with the gall bladder, the two main and several collateral divisions of the hepatic duct, the cystic duct, and the common duct with its entrance into the duodenum.

mass occupying the upper right abdomen. The next morning he began to complain of pain in the lower abdomen and, while the possibility of a second gall-bladder perforation was entertained, surgery was deemed inadvisable because of the patient's poor condition. Shortly afterward he experienced a chill lasting twenty-five minutes; the temperature rose to 105° F. (rectally); pulse, to 140; and the blood pressure dropped from 130/80 to 110/70. Emergency treatment against peripheral vascular collapse was instituted, but within several hours the patient expired.

Autopsy was performed by Dr. I. Davidsohn, Mount Sinai Hospital, Chicago, Ill. The abdomen was distended and the upper right quadrant was occupied by a fluctuant bulging mass, 16 by 15 cm., the entire length of which was traversed by a surgical scar. Free bile, about 100 c.c., was present in the peritoneal cavity and the omentum and both peritoneal layers showed a yellowish green discoloration. The right subdiaphragmatic space also contained some free bile. The lower surface of the right diaphragm was also discolored and the upper surface was diffusely hemorrhagic.

POSTOPERATIVE SIMULTANEOUS, BILATERAL, SPONTANEOUS PNEUMOTHORAX

CASE REPORT

THEODORE GOLDEN, M.D., NEW YORK, N. Y.
(From the Surgical Service, Harlem Hospital)

SPONTANEOUS bilateral pneumothorax is a bizarre and infrequent condition. Only ninety-five cases have found their way into the literature, to date, but there are probably as many more unreported or unrecognized. Excellent reviews, periodically, by McMahon,[1] Glickman and Schlomovitz,[2] and Hasney and Baum[3] have summed up the general subject adequately, while several exceedingly interesting case reports are recorded each year under this title.

An arbitrary classification of bilateral spontaneous pneumothorax has been made and the terms simultaneous or successive bilateral spontaneous pneumothorax are used, the former indicating that condition where collapse is demonstrated on both sides at the same time or on the opposite side before all air on the original side has been absorbed, while the latter denotes alternating pathology.[2]

ETIOLOGY

Davies[4] very neatly sums up the causes as: (1) injury to chest wall, bronchus, or lung; (2) rupture of emphysematous blebs, congenital or otherwise; (3) perforation as result of disease, with tuberculosis as the most common, followed by gangrene, abscess, and including malignant metastases. All the known causative factors may be placed in one of these groups, but it appears that a fourth group should be added including the so-called idiopathic bilateral spontaneous pneumothoraces occurring in apparently healthy individuals.

Of the latter, many theories have been advanced in an attempt to explain them, but Schmincke,[5] in 1925, suggested possibly the most logical theory and presented microscopic corroboration. He declared that cystic dilatations made up of vacuolated subpleural spaces due to faulty formation of lung tissue could be demonstrated. These spaces communicated with alveoli, and with rupture of the dilatations spontaneous pneumothorax occurred. Since these dilatations were bilateral, a bilateral pneumothorax was easily explained.

SYMPTOMATOLOGY AND DIAGNOSIS

Rarely the symptomatology is so mild that the condition goes unrecognized and untreated, being found accidentally during examination for another condition, but usually a sudden onset of dyspnea with

Received for publication, September 2, 1939.

Phillips,[7] the average duration of time from the onset of the attack to operation was twenty days. However, instances of sudden perforation with a formidable array of symptoms are to be found, but the diagnosis of this catastrophe is rarely considered, the most frequent diagnosis being perforated peptic ulcer, ruptured appendix, acute intestinal obstruction, and diffuse peritonitis of undetermined origin.

While most perforations are associated with the presence of stones in the gall bladder, instances of such rupture without presence of stones are recorded. Among the causes considered as leading to perforation are the following:

1. Overstretching, with or without stones.

2. Pressure of a stone upon the wall, causing ulceration.

3. Gangrene due to: (a) thrombosis of the vessels supplying the wall with or without stones; (b) circulatory obstruction due to pressure from stones; (c) diphtheritic, ulcerative infection of the wall, with or without stones; (d) carcinoma of the gall bladder; (e) infection passing through the wall, producing a localized pericholecystitis or pericholecystic abscess.

With both perforations the resulting symptomatology was practically the same; namely, pain in the shoulder due to diaphragmatic involvement, pain in the right lower abdomen simulating appendicitis due to seepage of the bile along the right trough into the pelvis with subsequent peritonitis and finally vesicle pain. The second perforation, while not entirely surprising, was unexpected because one month previously x-ray study had failed to reveal any stones present in the biliary system. Finally, the multiplicity of complications overcome by the patient is of medical interest, as is also the evidence establishing the fact that the peritonitis was not only in the nature of a response to chemical (bile) irritation but was rather of a true infectious type.

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CASE REPORT

J. R. (Hospital No. 111704), colored male, aged 17 years, was admitted to the Harlem Hospital, Dec. 8, 1938, with a history of having been taken suddenly ill the previous day with cramplike intermittent abdominal pain which started at the umbilicus and radiated to the right lower quadrant of the abdomen. There was no vomiting or untoward symptoms relevant to the other systems. The patient had had intermittent asthmatic attacks since the age of 2 years.

Physical Examination.—This was essentially negative, other than that relative to the abdomen and chest. The patient was apparently acutely ill. Abdominal tenderness was present below McBurney's point, with muscular spasm and rebound tenderness evidenced. There were many wheezy, harsh, sibilant râles heard throughout the chest. Clinical diagnosis: acute appendicitis and bronchial asthma.

Operation and Subsequent Course.—On Dec. 8, 1938, an appendicectomy was performed under spinal anesthesia. The appendix was found to be acutely inflamed. The patient's condition was quite normal until the fourth postoperative day, when an attack of asthma occurred. On the sixth day, Dec. 14, the temperature rose to 101.8° F. and moderate dyspnea developed, accompanied by intermittent substernal pain and attacks of coughing. The appendicectomy wound drained some serosanguineous material. Examination of the chest revealed scattered musical râles throughout with somewhat diminished breath sounds on the right.



Fig. 1. Fig. 2.

Fig. 1.—Marked spontaneous pneumothorax on right side. Broad adhesion at apex. Slight mediastinal shift to left.

Fig. 2.—Decompression needle in situ on right side with mild improvement in the pneumothorax. A moderate pneumothorax is seen on the left. This was not noted on immediate examination of the wet plate, but was recognized two days later when the roentgenograms were reviewed.

A roentgenogram of the chest at this time (Fig. 1) revealed a spontaneous pneumothorax on the right side with a broad adhesion at the apex and a slight mediastinal shift to the left. The intrapleural pressures were right side, minus 2, plus 3; left side, minus 10, minus 3; no decompression was attempted. On the following morning, the patient became markedly dyspneic and cyanotic. Three hundred cubic centimeters of air were aspirated from the right pleural cavity which resulted in some relief of the dyspnea.

By noon, the intrapleural pressure, right side, was minus 8, plus 3; 800 c.c. of air were withdrawn; pressure was minus 10, minus 3. Underwater drainage was established. Four hours later, the pressure was minus 12, plus 2, and 150 c.c. more of

chest pain, cyanosis, and occasionally a slight rise in temperature indicates, of course, careful examination and roentgenologic study. Often there is marked collapse and occasionally subcutaneous emphysema. The diagnosis is based on findings of diffuse or local hyperresonance, tympany, and diminished breath sounds, with roentgenologic corroboration.

TREATMENT

Most cases require no treatment, the increased pressure usually being sufficient to close the opening and the air or fluid becoming absorbed. If there is tension pneumothorax, prompt aspiration or closed drainage is indicated, while oleothorax is recommended in recurring cases for the formation of adhesions (Graham, Singer, and Ballon[6]).

Davies[4] suggests further that, in those cases where the rupture is held open by bandlike adhesions, there must be resort to thermocautery or pneumolysis and some cases will even require thoracoplasty.

It should seem that in the broad realm of surgery, with its rather common pulmonary complications, there would be frequent thoracic catastrophes falling into this classification, but it is surprising to find that only two such cases have been previously reported and both of these within the last year.

In the case of Phillips and co-workers[7] the patient was a 29-year-old male on whom a gastric resection for duodenal ulcer was performed. He was given gas, oxygen, ether anesthesia, and near the end of the operation developed a cervical subcutaneous emphysema. The diagnosis was made by roentgenogram and the treatment was expectant in nature. The condition proved to be self-limiting, being due probably to ruptured emphysematous blebs, and the patient made an uneventful recovery.

In the case of Gjanković[8] the patient was a young male also undergoing resection for duodenal ulcer. Splanchnic block was used, but a general anesthesia was finally required in the face of the patient's extreme restlessness. A midline incision extending to the xiphoid process was used and early in the course of the operation the patient became deeply cyanotic. It was decided to continue and at the close there was marked thoracic subcutaneous emphysema. Pneumothorax readings revealed bilateral positive pressures and repeated aspirations of air were instituted. The patient was discharged in good condition and the author, in recapitulation, felt that he had entered both pleural cavities inadvertently through anomalous pleural reflections at the xiphoid.

In each of the above cases the patient was otherwise an apparently healthy individual. In the case herein presented, the bilateral pneumothorax did not occur until a few days postoperatively, the patient was a known asthmatic, and the course was benign as presented.

Acute appendicitis; bronchial asthma; pulmonary emphysema; bilateral spontaneous pneumothorax; pleurisy with effusion, left chest.

Follow-Up.—Patient returned to clinic for dressings of left thoracotomy wound. He resumed normal activity and had no complaints other than occasional left chest pain and asthmatic attacks. Feb. 1, 1939, roentgenologic examination of the chest revealed almost complete absorption of the fluid in the left thorax with lipiodol markings over both lungs. Feb. 6, 1939, he was readmitted to Harlem Hospital during a rather severe asthmatic attack and at this time a small abscess was noted in the region of the left thoracotomy wound. The asthma was effectively treated



Fig. 5.

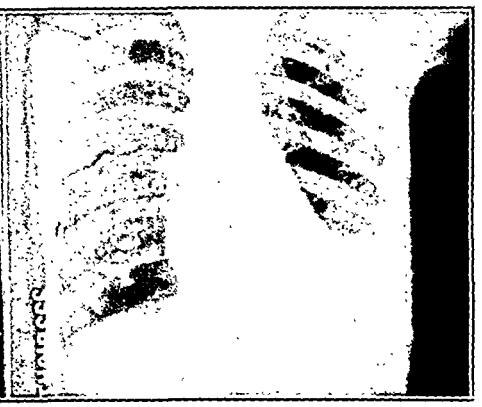


Fig. 6.

Fig. 5.—Pleural effusion on the left is beginning to be absorbed. Lipiodol seen on both sides.

Fig. 6.—Pleural effusion continues to be absorbed and above it the left lung is fully expanded.

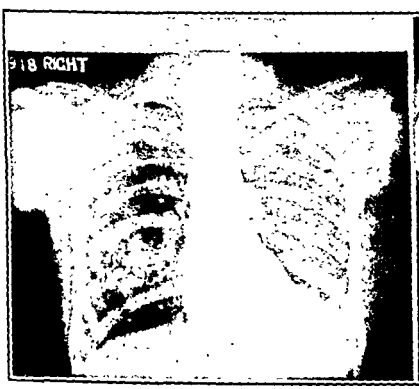


Fig. 7.

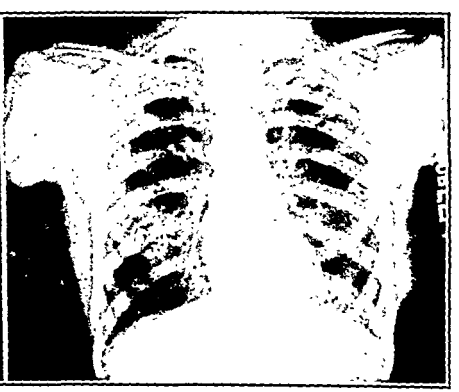


Fig. 8.

Fig. 7.—There is small amount of residual fluid in the left chest on discharge of the patient. Lipiodol markings seen on both sides. On the right side the interlobar fissure is outlined by lipiodol.

Fig. 8.—Both lung fields clear, except for persistent lipiodol markings.

with doses of adrenalin alternated with ephedrine. The abscess evacuated itself spontaneously and the patient was again discharged in good condition Feb. 16, 1939. On June 26, 1939, he returned to Follow-up Clinic and reported that he had had no complaints during the ensuing time. A roentgenogram at this time revealed only persistent lipiodol markings (Fig. 8).

air were withdrawn; pressure, minus 10, minus 2. Twelve hours later the pressure was minus 8, plus 2, and 400 c.c. more of air were withdrawn; pressure, minus 10, minus 2.

On Dec. 16, 1938, pressure was minus 8, plus 8, and 1,200 c.c. of air were withdrawn; pressure, minus 10, minus 0. Intercostal drainage was established and 10 c.c. of lipiodol was injected into the pleural space; pressure, minus 8, minus 2. Roentgenologic examination (Fig. 2) just prior to the insertion of the intercostal tube revealed slight improvement, but a moderate pneumothorax on the left side was overlooked at this time.

Two days later, Dec. 18, pressure was minus 1, plus 3; drainage tube was removed, cleaned, and replaced. The pressure oscillations were very small. At this time, the patient was somewhat dyspneic and distressed by an irritating cough. Percussion demonstrated hyperresonance over the left chest, with diminished breath sounds and scattered, distant, musical râles. Roentgenogram (Fig. 3) revealed full expansion of the right lung with lipiodol scattered over the lower lobe and a marked pneumothorax on the left. The intrapleural pressures were right side, minus 2, minus 0; left side, minus 10, minus 3. In spite of the negative pressure and because of the marked dyspnea, 400 c.c. of air were withdrawn with beneficial results.

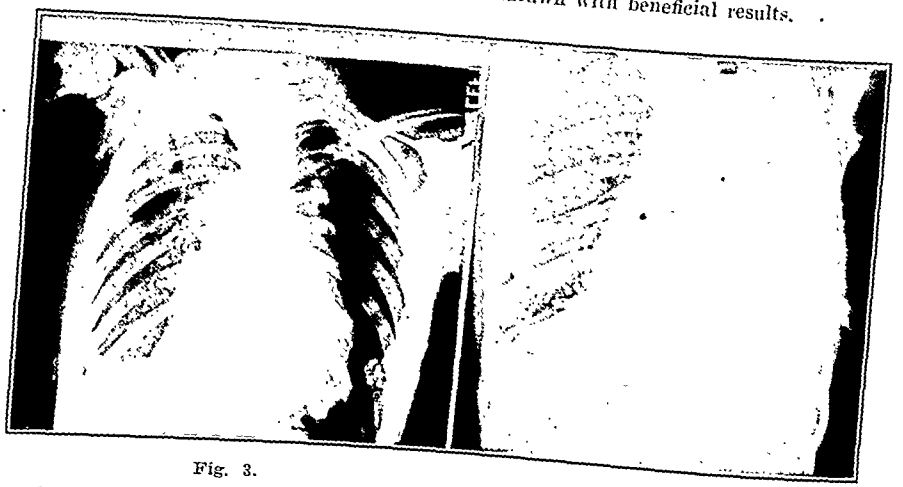


Fig. 3. Fig. 4.

Fig. 3.—Right lung expanded. Thoracotomy tube in seventh intercostal space and lipiodol scattered over lower lobes. Left lung is now seen to be almost completely collapsed.

Fig. 4.—Pleural effusion almost completely fills the left chest. Thoracotomy tube in situ on the left. Mediastinum moderately displaced to the right.

During the next two days the pressure readings fluctuated on the negative side, but the dyspnea was unimproved, necessitating repeated withdrawals of air on the left side. Dec. 21, 1938, it was decided to discontinue intercostal drainage on the right side and establish it on the left. This was done and 10 c.c. of lipiodol was instilled into the left pleural sac. This resulted in a marked pleuritic reaction with massive effusion (Fig. 4), which became apparent on the following day. The dyspnea increased and the intercostal tube was repeatedly plugged with fibrin, necessitating its removal. Dec. 22, 1938, the patient was improved, less dyspneic, and it was decided to refrain from a chest tap in order to avoid contamination of the fluid.

There was gradual improvement in the patient's local as well as general condition, and except for occasional pain in the left chest recovery was uneventful. Repeated roentgenograms revealed gradual absorption of the pleural fluid (Figs. 5, 6, and 7) and the patient was discharged Jan. 7, 1939, in good condition. Discharge diagnosis:

RECURRENT ECHINOCOCCUS CYST OF THE THIGH*

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ECHINOCOCCUS disease is an uncommon entity, save in portions of the world where sheep raising is a major industry; yet failure to consider the possibility of this diagnosis may prove embarrassing to the surgeon and a source of real danger to the patient. In the case to be cited, the diagnosis of echinococcus cyst of the thigh was not considered. At operation by the surgical resident the cyst was incised and the wound was contaminated with daughter cysts and, despite prophylactic precautions, the cyst recurred.

Prior to discussion of the case, we wish to quote freely from a recent detailed article by Dew:[1] "The *Echinococcus granulosis,* which inhabits the small intestines of the dog, measures 6 mm. in length and consists of a head and three or four segments carrying about 800 eggs in the terminal segment that are discharged into the bowel lumen. The dog became infested by eating the contaminated viscera of the sheep, ox, or pig. While man is also an intermediate host, since his infected flesh and viscera is not available to the dog, mans" is a dead end infestation. The manner in which man becomes infested was discussed in detail; such means as contaminated water and foodstuffs were thought to play minor roles. Dew feels that the most important source of infestation is the hands soiled in petting an infested dog. The chitinous covered eggs, 35 mm. in length, are swallowed. The gastric and intestinal juices free the active portion, which bores through the gut wall, enters the portal system, and, dependent upon passage of the liver, reaches the pulmonary circulation which, if successfully passed, allows any portion of the body to become the site of a mother cyst. In Dew's series the following sites are reported:

Liver	76.6%
(The right lobe of the liver was involved in 80% of above group and in 70% of instances there was an abdominal projection)	
Pulmonary	9.4%
Muscular and subcutaneous	5.2%
Kidney	2.3%
Spleen	2.1%
Bones	0.9%
Orbit	0.7%
Brain	0.6%
Other sites	2.2%

In man the active head develops a cyst wall surrounded by a cellular reaction area laid down by the host. Eventually within the cyst perpetuation of the cestode is attempted by appearance of daughter cysts.

*Presented before the Philadelphia Academy of Surgery, October 9, 1939.
Received for publication, September 13, 1939.

SUMMARY

An interesting and very uncommon postoperative pulmonary complication, together with a short review of the literature, is presented.

The two similar previously reported cases are reported in abstract.

In this case the bilateral spontaneous collapse was due undoubtedly to ruptured emphysematous blebs.

The treatment as outlined here is suggested for that case where expectant therapy or simple decompression is ineffective. The lipiodol is used as an irritant, causing a sterile pleuritis with resultant closure of the rupture.

In all recorded cases the prognosis has been good, except where the etiologic factor has been tuberculosis or similar chronic pulmonary pathology.

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pierced the muscles and extended towards the femur was a tongue some 4 inches by 1 inch by 1 inch. Spillage did not complicate this procedure. The pathologist reported a mother cyst with multiple daughter cysts within the excised tissue. The patient was again carefully followed for a period of five years. At his last visit the chest was again negative for disease, a complement fixation test was negative, and the site of operation was negative save for muscle hernia due to loss of fascia. Wassermann and Kline tests were negative also. The complement fixation test for echinococcus disease is negative if there is retention of hydatid fluid within the cyst walls since there will then be no circulating complement. This feature makes this test of less significance. Because of the reappearance within eighteen months and the fact that now after five years there is no reappearance of the lesion, it seems reasonably sure that the patient is disease free from *Echinococcus granulosis*.

COMMENT

This case has been reported because the experiences which we had point out the pitfalls in dealing with an entity uncommon in this country. The diagnosis was not considered and, after too short a follow-up period, cure was reported, failures we believe to be of value and worth reporting. This case calls attention to the fact, then, that any cystic mass may be echinococcic in origin. One does not expect the disease to ever attain even endemic proportions in this country due to the rigid care in the abattoirs in both the acceptance of animals for food purposes and the disposal of the entrails and viscera during the processing of the meat. An interesting feature of both the initial lesion and the recurrent one is that each was a mother cyst with multiple daughter cysts, which is a contradiction to the reports by Dew. He has stated that, when the rupture[2] of a cyst occurs, secondary cysts are simple cysts and rarely larger than hen's eggs. The initial cyst was clearly not of secondary origin but must have been caused by a single infective scolex passing all barriers to reach the subcutaneous tissues of the thigh. The operative rupture caused spillage and secondary cysts, which, in this instance, does not conform to Dew's dictum, since it was again a mother with multiple daughter cysts and it recurred within a period of eighteen months and had attained nearly the size of the initial cyst. If the original invader had been present since infancy, certainly the operative interference caused the recurrent cyst to grow at an inordinate rate. This makes one wonder if the first lesion was not implanted some few years before it was first noticed. It is not the desire to dispute so distinguished an authority as Dew, but where contrary findings are to be found they should be so reported.

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The aforementioned cyst wall is selectively permeable, preventing the entrance of noxious materials which might kill the cysts. The daughter cysts vary from undifferentiated cellular masses to those which contain well-differentiated scolices. Dew believes that infestation occurs in childhood in a majority of instances and thus the cyst is nearly as old as the patient. This extremely slow rate of growth is a feature not appreciated by most.

The diagnosis is not difficult where the condition is epidemic. In other localities, keeping the possibility of the infestation in mind is perhaps the most important point, since the features which differentiate it from other masses cystic in type may then be considered. Laboratory aids are the x-ray and the complement fixation test of Fairley, in which fresh hydatid fluid from sterile sheep cysts is used as antigen. Formerly the intradermal test of Casoni and the precipitin test of Flieg and Lisbonne were used, but with variable results.

The treatment is en bloc excision when the site of the disease permits, exercising the greatest of care to prevent spillage into fresh wounds. When this procedure cannot be done, marsupialization and treatment of the cyst wall with formalin must be done. This method is to be avoided wherever possible since there may be a draining sinus for months or years.

CASE REPORT

The patient was an Italian male, 48 years of age, who, because of dislike of dogs dating from childhood, had always avoided them. Three years before the initial admission, he had noticed a slowly growing fluctuant mass 10 by 12 by 6 cm., nontender, on the lower outer aspect of the right thigh. When the skin over it became reddened, he sought medical advice and was admitted to the surgical service of the late Dr. John Speese in the Presbyterian Hospital. History and examination plus normal laboratory findings pointed to a diagnosis of lipoma. The x-ray report was positive for a soft tissue tumor. In attempting to enucleate the tumor, the surgical resident broke through a cyst wall, at which time the true diagnosis was made. There was spillage. The wall of the mother cyst was completely excised and the wound carefully washed out with formalin solution. The wound healed without incident and the patient was discharged on May 29, 1932.

The pathologist reported echinococcus cyst with multiple daughter cysts. X-ray studies were made of lung and bone without finding lesions. He was given periodic physical and laboratory examinations, including x-ray, for a period of eighteen months. Attempts at culture, as suggested by Dew,[2] were made in three rabbits, but we were unable to transmit the disease in any instance. At the conclusion of this follow-up period, Dr. John Speese and I[3] reported the findings as an apparent cure.

The patient reappeared in May, 1935, with a recurrence at the site of the original lesion. As on previous admission, physical findings, save a cystic lesion 8 by 8 cm., and laboratory studies were not helpful or significant. He was submitted to surgical exploration on May 22, 1935 (by J. B. M.) and a careful en bloc excision of the recurrent echinococcus cyst was carried out. The lesion in this instance extended from just above the level of the joint line on the outer aspect of the right thigh upward and inward spreading muscle bundles until it almost reached the femoral shaft at its midportion. The proportion of the cyst which

took advantage of the Foley-Alcock catheter (*21*) and its counterpart, the two-way four-winged self-retaining female catheter (*22*). This allowed a separate direct intake (*2*) for constant irrigation. The intake, adjusted at three times the reservoir filling drip (*3*), assured a faster rate of bladder than reservoir filling. Many other types of siphon-breaking devices, such as flutter valves, rubber and glass air traps, and various combinations of siphon and reservoir were tried. These attempts further to imitate the normal filling mechanism of the normal bladder by entirely eliminating the latent period were unsuccessful.

The use of the self-retaining catheter not only made constant irrigation possible, but by internal fixation assured uninterrupted and dependent bladder drainage at all times. Such internal fixation reduced urethral friction since the catheter was thus independent of body motion. The coincident elimination of adhesive strapping facilitated drainage of any urethritis which might be present. By using a small catheter (No. 18 F.), urethritis and prostatitis were further reduced to a minimum.

Our apparatus, modified from Monro's as above described, operates as follows: From the two-liter flask (*1*), the irrigating fluid goes through the intravenous dropper (*2*) directly to the bladder as a constant intake. At the same time, fluid is dropping through the Murphy dropper (*3*) into the larger tube (*11*) to the reservoir bottle (*4*) at one-third the rate. This glass tube lead is loosely sleeved inside the larger tube to allow changing of the siphon height. In Fig. 1 the reservoir intake is shaded out to show that the apparatus may be further simplified by its omission. If omitted, the reservoir intake tube becomes strictly an air vent and manometer, and its caliber 4 to 5 mm. instead of 10 mm. This manometer tube ends directly through the rubber cork in the reservoir bottle (*4*). The outlet of the bottle is a glass tube (*5*), extending nearly to the bottom and having a partially fused end (*6*) between ¾ and ½ mm. This connects with the T-tube (*7*) through *8*. The upper limb of the T-tube is the siphon (*9*) and the lateral limb is the bladder outlet from the main tube (*10*) of the catheter. Fluid rises in the reservoir or siphon-breaking system (*6*, *5*, *7*, *8*, *12*) until it reaches bladder level, usually at *13*, after which the intravesicular pressure builds up gradually to the height of the siphon (*9*). When fluid goes over the siphon bend, tripping the emptying mechanism, it begins drawing fluid both from the reservoir system (*6*, *5*, *7*, *8*, *12*) and from the bladder simultaneously. The pull on this system goes through the partially-fused end (*6*) whose diameter is approximately one-third that of the smallest constriction in the catheter and bladder outlet tubes. The speed of withdrawal of fluid from the bladder is greater than that from the reservoir system by several times.*

*Poiseuille's Law: "The speed of currents in capillary tubes is proportional to the square of their diameters."

A TIDAL IRRIGATOR*

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WHILE using Monro's[2] tidal irrigator on paralytic bladders in the Department of Urology, we were impressed with the amount of nursing and intern care required to keep the apparatus functioning properly. There appeared to be several undesirable features involved in the mechanics of it which we felt might be corrected. It also seemed practical to modify its construction sufficiently to allow more forms of irrigation and to make provision for cystometric studies without necessitating transportation to the clinic or the use of a second apparatus. Certain modifications of the Monro tidal irrigator were made which seemed to eliminate these difficulties.

The rubber tubing and glass connections of Monro's tidal irrigator were unstable. They easily became air-bound or kinked, resulting in disturbance or failure of siphonage. Adjustments of siphon and siphon-reservoir bottle height were difficult in adaptation to the changing needs of the patient from day to day. Consequently our irrigator was constructed on an adjustable and protective mounting as shown in Figs. 1 and 2. Rubber tubing was replaced with glass tubing so that stoppage by kinks and by becoming air-bound was eliminated. The resulting transparency made it easy to check the patency and efficiency of the system at a glance. The siphon height could be changed by loosening the thumbscrew (*13*). Not only did this allow fine adjustment, but it facilitated changing of the siphon height by any attendant when the patient was able to sit up in a chair. The protective mounting, as shown, has made breakage rare. In practice, the apparatus has been found to be quite foolproof and requires a minimum of care and comprehension.

Other disadvantages of the original irrigator which we sought to eliminate were the prolonged latent period and reflux. Between the time the siphon had broken, after emptying the bladder, and the time the level of fluid in the siphon and reservoir reached bladder level, drainage from the bladder was by gravity into the reservoir bottle (*1*). This created a latent period during which no bladder irrigation took place. Consequently, no dilutent or bacteriostatic fluid entered the bladder to match the ureteral output during that time. When irrigation did take place, the residual contaminated drainage in the tube leading from the catheter, was first refluxed back into the bladder ahead of the irrigating fluid. To reduce the latent period and prevent reflux, we

Received for publication, July 26, 1939.

the capacity of the reservoir system may be several times less than that of the bladder and still empty after the bladder has emptied. As soon as the reservoir system is empty, air rushes into the siphon through *6*, having a free communication with the outside through the reservoir intake tube or manometer (*11*), and siphonage is interrupted. Residual urine may be found by measuring the fluid deposited in *4* by agitation of the catheter while suprapubic pressure is exerted immediately after the siphon has broken. If the amount is significant, it means that the reservoir system is too small for the bladder capacity, and the easiest remedy is to make the fused end at *6* smaller. The height of the siphon, and therefore the capacity (and intravesicular pressure) in centimeters of water, may be varied to suit the particular stage or type of bladder as determined by cystometry.

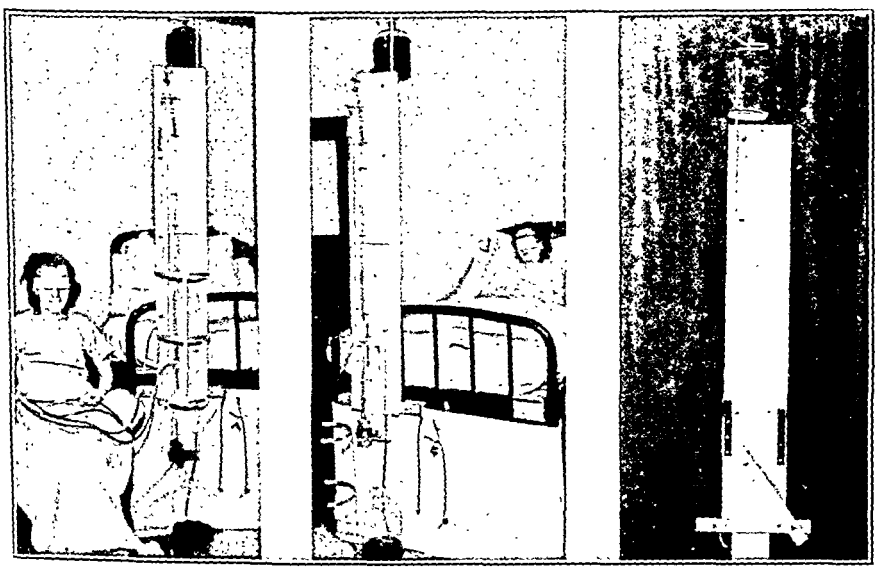


Fig. 2.—Irrigator in use with patient in bed, and in chair, showing advantage of adjustable siphon level (case of cauda equina bladder with infection).

All other forms of irrigation, except quick intermittent flushing, may be attained in the following manner: If constant siphonage is desired, with or without continuous irrigation, a clamp is placed on the rubber joint at *12*, cutting out the siphon-breaking reservoir system. The height of the siphon is immaterial.* If gravity drainage is wanted, the reservoir bottle (*4*) is removed and the lower end of the T-tube at *5* is connected to the waste bottle with a rubber tube. At present a clot trap is being constructed to be inserted at the lateral limb of the T-tube as it connects with the main tube to the catheter outlet so that it may be used routinely on postoperative patients. Emptying at low intravesicular pressure would be desirable so the siphon should be barely above bladder level.

In addition, the center of level of the reservoir system is about one-third as high as that of the bladder and therefore subjected to less than one-third the siphonage exerted on the bladder.* It follows that

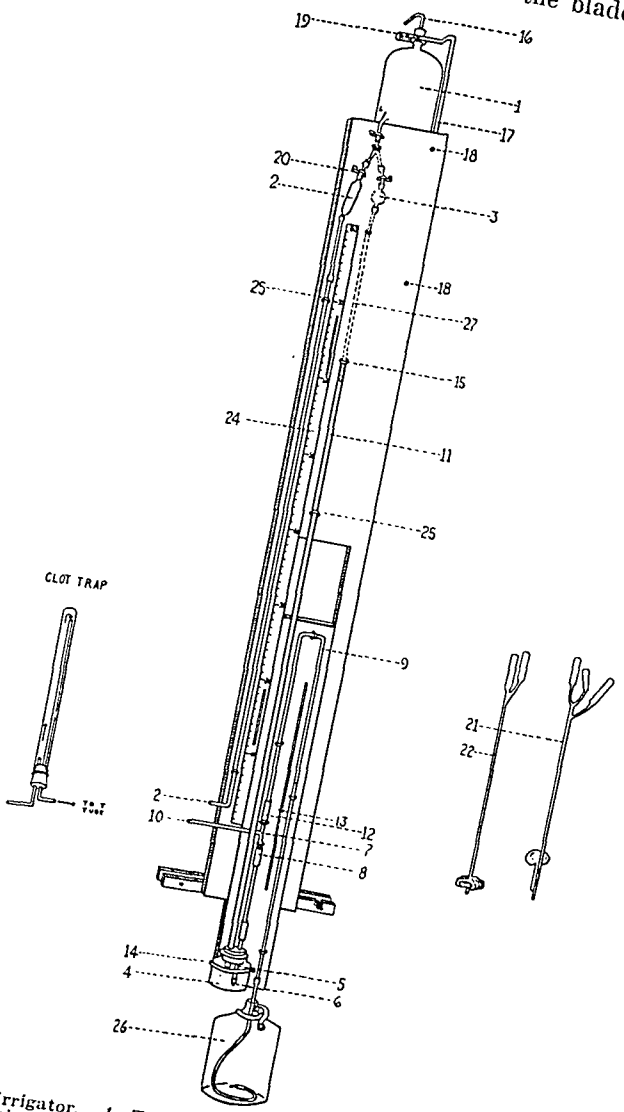


Fig. 1.—Tidal irrigator. *1*, Two-liter flask; *2*, intravenous dropper; *3*, Murphy dropper; *4*, reservoir bottle; *5*, glass tube; *6*, partially-fused end of glass tube; *7*, T-tube; *8*, rubber joint; *9*, siphon; *10*, main tube from catheter; *11*, manometer; *12*, rubber joint; *13*, thumbscrew; *14*, thumbscrew clamp; *15*, rubber band; *20*, Hoffman clamp; and U-tube; *17*, bottle rack; *18*, thumbscrew; *19*, rubber washer; *16*, cork *21*, Foley-Alcock catheter; *22*, Two-way, four-winged, self-retaining, female catheter; *24*, 80 cm. metric ruler; *25*, glass-holding bracket; *26*, 1-gallon jug; *27*, glass tube.

*A corollary to Pascal's Law concerning the dependency of depth of fluid in the transmission of pressure equally in all directions. The corollary from this law is the law of siphonage which states that the pressure is a function of the difference between the levels of the liquids involved and is proportional to the square of the diameter of the siphon used.

where irrigation seemed desirable, until at present it is replacing all other forms of irrigation of cord bladders. In using tidal irrigation, it is difficult for us to agree that this form of irrigation, simulating the emptying mechanism of a normal bladder as it does, has any effect of "education" toward the desired, so-called normal reflex type of cord bladder with a small residual urine. We prefer to believe that it helps (a) to retard the retrograde progress of infection from the bladder through the pelvic to the ureteral and renal lymphatics to its usual conclusion, by reducing vesicular infection when present; (b) to ablate residual urine where high and thus tend to prevent infection

List of Materials for One Irrigator

MATERIALS

1 piece of white pine, 52 inches by 8 inches by 1⅛ inches
1 piece of white pine, 26 inches by 4 inches by 1 1/16 inch by ½ inch
2 pieces of birch, 12½ inches by 1 inch by ¾ inch
1 piece of bar scrap iron for guard (*see* Fig. 1) 65 inches by ⅝ inch by ⅛ inch
1 piece of bar scrap iron for bed hooks (*23*) 24 inches by 1 inch by ⅛ inch
1 piece iron rod for 2-liter flask holder (*17*) 36 inches by ⅜ inch
2 2½ inch by 2 inch flat-head stove bolts
2 ½ inch by 4 inch round-head stove bolts
5 ¼ inch wing nuts (*18, 13*)
5 ¼ inch square nuts
5 ¼ inch iron washers
1 flat-head stove bolt with sing nut and washer 7/16 inch by 2½ inches
3 No. 8 1 inch flat-head iron screws, 11c gr.
6 No. 10 1 inch round head iron screws, 12c gr.
30 No. 3 ⅜ inch round head iron screws 09c gr.
4 ft. electrician wire solder for glass-holding brackets (*25*)
1 piece 7 inches by ⅝ inch by ⅛ inch brass or iron for bottle clamp (*14*)
1 wooden metric ruler 80 cm. long split (*24*)
⅛ pint varnish

GLASSWARE

1 2-liter male aspirating bottle (*1*)	$0.80
1 T-tube 4 *mm.* (*7*)	0.15
1 one-hole rubber stopper No. 3	0.02
2 Hoffman clamps (*20*)	0.20
1 IV drip bulb (*2*)	0.25
1 Murphy drip (*3*)	0.09
1 Y-connecting tube	0.08
3 ft. 0.8 cm. glass tubing (*11*) or 1 cm. if reservoir intake is to be used	0.03
2 70 cm. 4 mm. glass tubing (*25* and *27*)	0.06
4 15 cm. glass tubing	0.03
2½ ft. 4 mm. glass tubing	0.03
1 solid rubber stopper, No. 9	0.10
1 100 c.c. specimen bottle (*4*)	0.15
1 1-gallon jug (*26*)	0.15
25 cm. rubber tubing—IV 6 mm.	0.08
6 8 ft. rubber tubing, red, ¼ inch by 3/32 inch	1.44
2 glass connectors 3 inches by 5/16 inch	0.08
	$3.72

Carpenter labor	9 hr.	
Metal worker	1 hr.	
Painter	½ hr.	
Approximate labor cost		$8.86
Material cost		3.48
Glassware costs		3.72
Complete total cost		$16.06

The bottle (*1*) may be removed for cleaning by loosening the thumb-screw clamp (*14*). The rubber washer (*15*) is for dust-proofing the reservoir intake. The cork and U-tube (*16*) dust-proofs the two-liter bottle. The bottle rack (*17*) may be removed by loosening the thumb-screws (*18*) for transporting the patient through low doors. The bottle is held to the rack (*17*) by a strong rubber band (*19*). The Hoffman clamps (*20*) adjust the rate and ratio of fluid intake into the two systems. The tube clamps are made of welding wire and the bottle rack of rod iron. The rest of the materials and dimensions and costs appear at the end of this paper.

The apparatus is easily sterilized by running a 1:1,000 solution of mercury oxycyanide through the system with the catheter attached and placed in a convenient-sized basin for simultaneous sterilization. Distilled water or boric is used for thorough rinsing.

It is especially valuable to recheck by cystometry the progress or regression of paralysis so that the height of the siphon may be varied accordingly. If the capacity is lessened, the height is increased; if increased, it is lowered. Should paralysis regress to the desired normal reflex type of cord bladder with a low residual, and, if infection has been minimized, irrigation should be discontinued. Cystometry is accomplished by placing a hemostat at the rubber joint (*12*) cutting out the siphon. The partially fused end (*6*) is removed from the reservoir bottle to allow full oscillations in the manometer. The direct intake (*2*) is turned off and the centimeter ruler adjusted with its zero point at the level of the symphysis pubis. The T-tube is raised to the same zero point and the reservoir system filled until spill into the bladder is ready to occur. Since no graduated two-liter bottles are available at present, the bottle (*1*) must be replaced with an ordinary 1,000 c.c. graduated Kelley flask to measure the fluid used. By letting in fluid at (*2*) at a constant, moderately fast drip, direct manometric readings may be taken in centimeters of water in tube (*11*), usually after every additional 50 c.c. has run in. If a small manometric tube is used by eliminating the Murphy dropper intake, greater manometric excursions result and the readings become more accurate. To empty the bladder and measure accurately the amount withdrawn, a hemostat is placed at *8* and then the one removed from *12*. The siphonage is measured in the waste bottle.

Paralytic bladders have recently been reclassified in detail by McLellan.* It is not within the scope of this paper to enter into the controversy of irrigation vs. nonirrigation of cord bladders in the management of the various forms or stages of this distressing condition. At present even the atonic bladder is being irrigated with success.

Since its inception in June, 1937, the apparatus has been used off and on in University Hospital in the treatment of paralytic bladders

*For a full discussion, see McLellan.[1]

LOCALIZATION OF OCCULT LIVER ABSCESS DURING LAPAROTOMY UNDER PROCAINE INFILTRATION ANESTHESIA

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(From the Department of Surgery, the Johns Hopkins University)

THE classical symptoms and signs of liver abscess are sufficiently well known. Equally appreciated is the difficulty in locating an abscess in the liver. A small abscess may not be visible on the surface of the liver, nor can it be palpated with the exploring finger. Our experience with a recent case treated in the Johns Hopkins Hospital may afford a means of localizing such small abscesses.

CASE HISTORY

S. W. (Unit 156859), negro, male, 42 years of age, came to the hospital on Nov. 1, 1938, complaining of weakness and pain in the lower right chest and upper right abdomen. He stated that his mother and one brother were known to have diabetes mellitus. Seven years previously an appendical abscess had been successfully treated. He also stated that during his naval service in the past war he was ashore in both South America and the West Indies. He dated the onset of his present illness to September, about eight weeks before admission, when he first noticed weakness, thirst, and frequency of urination. Three weeks before admission he began to have pain in the lower right chest. During the past month he also noticed loss of appetite, fatigability, and loss of twenty pounds in weight.

Physical examination on admission showed a large, muscular negro who was sweating profusely. His temperature was 100°; pulse, 76; respirations, 24; blood pressure, 124/80. Examination of the head, neck, and chest revealed no abnormalities. The upper part of the abdomen was tender. There was muscle spasm in the right upper quadrant and an easily palpable, round mass which descended on respiration from beneath the costal margin. This was acutely tender. The remainder of the abdominal examination was negative. The diaphragm was not elevated on either side. Urinalysis showed a large amount of sugar, acetone, and diacetic acid. Examination of the blood revealed: hemoglobin, 66 per cent; 18,760 leucocytes per cubic millimeter; 376 mg. per cent of glucose; carbon dioxide combining power, 51.3 volumes per cent; nonprotein-nitrogen 27 mg. per cent. Examination of the stool failed to show parasites or amoebae. X-rays of the chest and abdomen were read as normal. The admission diagnosis was liver abscess, probably amoebic, and diabetes mellitus.

The patient was immediately subjected to vigorous treatment for the control of the diabetes, and by the following morning his blood sugar had fallen to 251 mg. per cent and there was no acetone or diacetic acid in the urine. At the same time his temperature had risen to 104°. The abdominal mass was somewhat more tender and it was felt that this might represent an acutely inflamed gall bladder on the point of perforation. For this reason an emergency operation was decided upon. A laparotomy was done with local infiltration of procaine as the anesthetic agent. A right rectus incision was made directly over the mass. This mass proved

Received for publication, August 7, 1939.

in certain types of bladders; (c) to keep the bladder musculature from distortion, contracture, or hypertrophy; (d) to add to the comfort of the patient; and (e) to facilitate nursing care. In other words, we prefer to look upon its function as that of any other form of physical therapy to a paralyzed muscle in helping to prevent deformity and preserve its relationship to as close to normal or physiologic as possible. The frequency of emptying, the intravesicular pressure (controlled by height of siphon), and the solution used in irrigation then must be varied to suit the individual type of paralytic bladder and the type and degree of infection present. If the paralysis is temporary and the "infantile" (uninhibited[1]) type of cord bladder, or normal reflex with low residual urine is attained, the physical therapy of the irrigator in the interim theoretically reduces the amount of irreparable damage to a minimum.

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The patient was then followed in the Out-Patient Department. The finger did not heal. An x-ray taken on March 8, 1939, finally showed that there was chronic osteomyelitis with a large sequestrum in the proximal phalanx of the middle finger. This finger was amputated under cyclopropane anesthesia on March 31, 1939. The patient's last visit was on April 11, 1939, at which time the wound had healed and the patient was well.

There are several interesting points which I wish to make in connection with this case. In the first place, the observation of localized tenderness over a small intrahepatic abscess to my knowledge has not been described before. This observation can be made only when the operation is carried out under local infiltration anesthesia. Second, while numerous cases of liver abscess due to Friedländer's bacillus infection have been reported, the mortality has been high. It is a matter for speculation whether the successful outcome in this case was due to prompt surgical drainage, or sulfapyridine therapy, or both. Third, the high degree of infectivity of Friedländer's bacillus is worth remarking upon, so that such infections will be treated with proper respect. Not only did this patient develop a deep finger and hand infection, with loss of the finger, but also the house officer in charge of the patient developed a severe throat infection with Friedländer's bacillus. Following hospitalization and sulfapyridine therapy, his recovery was prompt and complete.

to be the swollen, rounded edge of a greatly enlarged right lobe of the liver. The gall bladder, stomach, and other intra-abdominal viscera were all normal in appearance and on palpation. The surface of the liver was carefully palpated with the finger and no area of bulging or softening could be detected. There was one area about 2 cm. in diameter in the midportion of the right lobe which seemed to be exquisitely tender when palpated. This observation was verified several times. The patient who was, of course, quite conscious, was able to state that he had severe pain immediately when this area was palpated. It seemed likely, therefore, that the liver abscess might lie in this region. The general abdominal cavity was walled off with gauze packs. An aspirating needle was inserted into the liver. At a depth of about 3 cm. thick yellow pus was obtained. An incision was then made through the liver and an abscess cavity containing about 150 c.c. of yellow pus opened. Cultures were taken. One cigarette drain was inserted into this abscess cavity and a second drain placed along the edge of the liver in such a manner as to protect the general peritoneal cavity. The wound was then closed.

Direct smear and culture of the pus resulted in a pure growth of the gram-negative encapsulated bacillus of Friedländer. During the next seventy-two hours the patient's temperature varied between 100 and 102.8°. His diabetes was difficult to control; but, while there was still sugar in the urine, there was no acetone or diacetic acid. On the fourth day after operation, the administration of sulfapyridine was begun on the advice of Dr. Perrin Long. The patient was given 0.6 gm. every six hours by mouth. At this time the leucocyte count was 24,000. During the next twenty-four hours there was an immediate fall in temperature, the highest temperature being 100.4°, and from the fifth postoperative day onward the temperature never rose above normal. The drains were removed on the seventh postoperative day. Sulfapyridine therapy was discontinued on the thirteenth postoperative day. The hemoglobin at this time was 62 per cent and the leucocyte count was 7,550. On the nineteenth day after operation, cultures of the material draining from the wound were negative for Friedländer's bacillus, and the patient was permitted to get up. His diabetes was now well regulated by the administration of fifteen units of insulin daily.

He was discharged on Nov. 22, 1938. The diabetes was well regulated by diet, no insulin being necessary at this time. There was still slight discharge from the wound.

During the first week after leaving the hospital, the patient developed pain, swelling, and tenderness on the dorsum of the proximal phalanx of the left middle finger. This was incised by a physician elsewhere. The patient returned to this hospital on Nov. 29, one week after discharge. His temperature was 103°; the leucocyte count, 11,800. The chief observation of interest at this time was the edema, redness, and tenderness of the middle left finger and dorsum of the left hand. There was a draining wound on the dorsum of the proximal phalanx. His diabetes was again out of control and the blood sugar was 354 mg. per cent. It was felt that the finger infection was insufficiently drained. Under cyclopropane anesthesia incisions were made on either side of the middle finger, extending into the lumbrical canals and midpalmar space. A large quantity of yellow pus was obtained. The infectious agent on culture again proved to be Friedländer's bacillus. Sulfapyridine was again administered, and the diabetes brought under control by the use of fluids and insulin. The finger rapidly improved, and the patient was discharged on Dec. 15, 1938. At this time there was still a small draining wound on his finger, the swelling had diminished decidedly, and the diabetes was under control without insulin. The abdominal wound had ceased draining and was completely healed.

During the first twenty-four hours postoperatively, he responded fairly well and was able to take fluid by mouth. On examination he showed a third nerve palsy on the left side, although this pupil was smaller than before operation. In addition he had a left facial weakness of central type, weakness of the left arm and left leg with increased tendon reflexes on this side and a positive Babinski reflex. During the next twelve hours, he became more drowsy and his temperature rose to 102° F.; pulse, to 120; respirations, to 24. Tapping the wound failed to obtain either blood or fluid and one could feel a tense dura.

He was again taken to the operating room and under local anesthesia the right side of the head was prepared for operation. A trephine opening was made in the right temporal region and clotted blood was encountered under the bone. This opening was enlarged and a hematoma approximately 3 cm. deep was found to extend anteriorly and laterally over the frontal lobe to the midline as well as underneath this portion of the brain. The middle meningeal artery could be seen

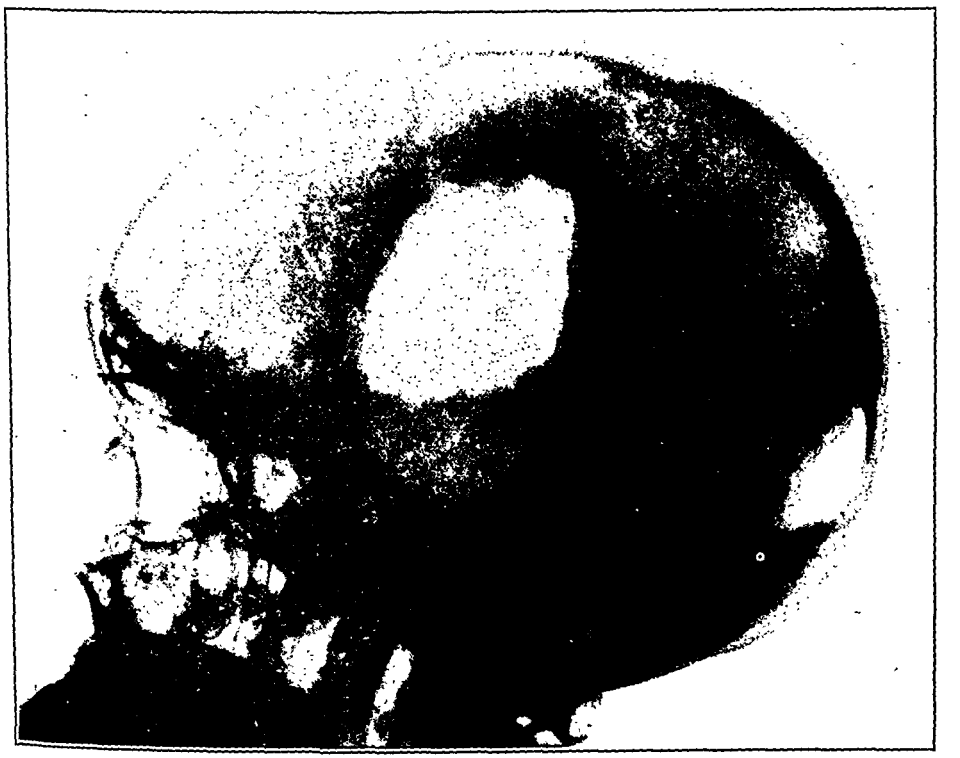


Fig. 1.—X-ray taken postoperatively, showing the bony openings. The larger of the two is on the right side where a decompression was made. Part of the line of fracture in the frontal bone can also be seen.

after evacuation of the clot. It had been torn at the foramen spinosum, but was not bleeding. The brain and dura expanded rapidly. In order to combat the cerebral edema, which was sure to follow, the dura was opened widely. Underneath the dura was a small clot which had arisen from a laceration near the tip of the temporal lobe. This clot was removed, bleeding points on the dura were cauterized, and the wound was closed without drainage with fine silk.

During the next twenty-four hours, he improved rapidly and responded well. The third day after this operation one could no longer detect weakness of the arm or leg and the Babinski sign was negative. The third nerve palsy was

A CASE OF BILATERAL EXTRADURAL HEMORRHAGE

PAUL A. KUNKEL, JR., M.D., HARRISBURG, PA.

ALTHOUGH the subject of epidural or extradural hemorrhage of traumatic origin and its surgical treatment is well known, the fact that the lesion may be bilateral is seldom mentioned and apparently of rather rare occurrence in the literature. LeCount and Appelbach[1] found in 504 post-mortem examinations of patients dying of head injuries, 104 extradural hemorrhages of sufficient size to cause compression of the brain and death; 1 of these was bilateral. Munroe[2] in 1935, discussing the treatment of head injuries, states that the lesion may be bilateral, but in his 22 cases of epidural hemorrhage there were apparently none that were bilateral. In a recent review of the subject Verbrugghen[3] does not mention the possibility. On the other hand, Pringle[4] had, in a series of 33 cases, 3 cases that at post mortem were found to have bilateral extradural hemorrhages of traumatic origin, an incidence of 10 per cent, which naturally brings up the question of whether the bilateral occurrence is as rare as it is generally thought to be. It is well known that bilateral subdural hematoma is of fairly frequent occurrence (Frazier[5]). Perhaps if looked for more often, bilateral extradural hemorrhage would be found more frequently. It is with this in mind that the following case is reported.

CASE REPORT

R. B., colored, male, aged 33 years, was admitted to the Harrisburg Polyclinic Hospital on Feb. 10, 1939, shortly before midnight. The history as obtained from his wife was that a few hours before he had come home complaining that he had been struck with a brick and within a short time had lapsed into coma. On examination he was found to be in deep coma. Temperature, 98° F.; pulse, 30; respirations, 10; systolic blood pressure, 200. There was a hematoma over the right forehead and blood coming from the nose. Otherwise he showed nothing else on physical examination. On neurologic examination he failed to react to any sort of painful stimulus. There was no deviation of the eyes, but the left pupil was larger than the right one. All four extremities were flaccid. None of the superficial or tendon reflexes could be obtained. There was no response to plantar stimulation.

He was taken to the operating room, where his head was shaved, cleaned with iodine and alcohol, and both sides draped. A trephine opening was made over the left temporal region. A clot approximately 4 cm. deep was encountered under the skull. The incision and bony opening were enlarged, whereupon the clot was found to extend anteriorly and upward to the midline. It was evacuated and the middle meningeal artery, which had been torn across, was thrombosed by electrocoagulation as well as some of its branches. The rest of the oozing was controlled with hot normal saline solution and cotton. The brain and its dural covering by this time had nearly filled the space occupied by the blood clot. The remaining defect was filled with normal saline solution and the wound was closed without drainage, using silk throughout.

Received for publication, August 29, 1939.

During the first twenty-four hours postoperatively, he responded fairly well and was able to take fluid by mouth. On examination he showed a third nerve palsy on the left side, although this pupil was smaller than before operation. In addition he had a left facial weakness of central type, weakness of the left arm and left leg with increased tendon reflexes on this side and a positive Babinski reflex. During the next twelve hours, he became more drowsy and his temperature rose to 102° F.; pulse, to 120; respirations, to 24. Tapping the wound failed to obtain either blood or fluid and one could feel a tense dura.

He was again taken to the operating room and under local anesthesia the right side of the head was prepared for operation. A trephine opening was made in the right temporal region and clotted blood was encountered under the bone. This opening was enlarged and a hematoma approximately 3 cm. deep was found to extend anteriorly and laterally over the frontal lobe to the midline as well as underneath this portion of the brain. The middle meningeal artery could be seen

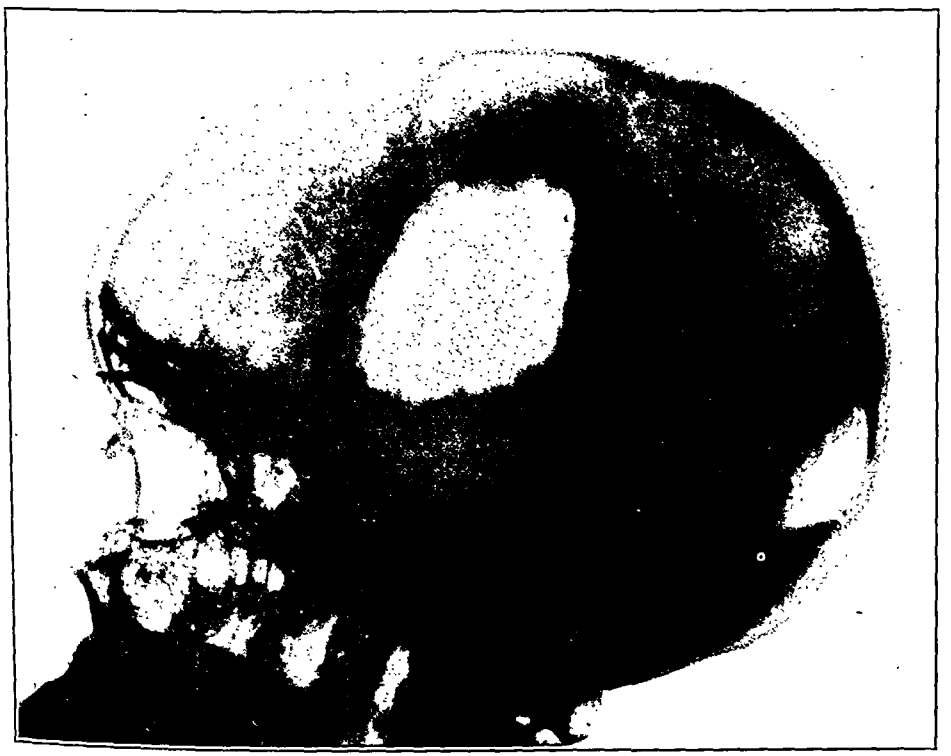


Fig. 1.—X-ray taken postoperatively, showing the bony openings. The larger of the two is on the right side where a decompression was made. Part of the line of fracture in the frontal bone can also be seen.

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During the next twenty-four hours, he improved rapidly and responded well. The third day after this operation one could no longer detect weakness of the arm or leg and the Babinski sign was negative. The third nerve palsy was

greatly improved. He was discharged on Feb. 21, 1939, twelve days after admission. At this time his neurologic examination was normal. He was seen again two months later, at which time he was free of symptoms and no abnormalities were detected.

DISCUSSION

The diagnosis in this case could be made rather easily and with some degree of certainty from the history and the fact that the patient was deeply unconscious. The treatment followed was that advocated by Dandy.[6] Any temporizing as pointed out by Dandy in the way of x-rays, lumbar puncture, or intravenous hypertonic fluids undoubtedly would have cost this patient his life. Although both sides of the head had been draped in case a gross hemorrhage was not encountered on the left side (the left pupil was dilated), in retrospect it would have seemed better to have trephined the right side following the evacuation of the left hematoma, as the hemorrhage on this side could have been safely evacuated and arrested at that time. However, as the dura on the left side had not expanded to the skull, it seemed better at the time to let well enough alone. The subsequent development of a left hemiplegia, stupor, and a rising temperature made an exploration on the right side imperative at the end of thirty-six hours. Again, any other postoperative therapy in the way of dehydration or lumbar puncture would undoubtedly have done more harm than good. The small subdural clot found with the second hematoma was probably of little significance. A decompression was carried out in order to relieve any cerebral edema which seemed certain to follow the trauma and compression to which the brain had already been subjected.

In summary, a case of bilateral traumatic hemorrhage successfully treated by the operative removal and the arrest of the hemorrhage and by a right subtemporal decompression has been described. It is emphasized that procedures, such as lumbar puncture, intravenous therapy, and x-rays, in any case of suspected extradural hemorrhage may be not only actually harmful in themselves but are also frequently the cause of the loss of valuable time in the evacuation of the hematoma and the arrest of the hemorrhage.

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Editorial

The Care of the Urinary Bladder After Operation

THERE is no organ in the body which so often plays the unhappy role of the innocent bystander who was accidentally injured as does the urinary bladder in the course of operations upon other unrelated organs. I refer, not to direct surgical trauma at the time of operation, but to the effects of neglected or mistreated postoperative retention of the urine. This complication is especially frequent after operations which confine the patient to bed. It is often described as "reflex," but it is actually due to a combination of three factors. First, many patients are unable to urinate in the horizontal position even when in good health. Second is the role of pain in patients with incisions in the abdominal wall or perineum. In such cases, contraction of the voluntary muscles of urination is painful, and hence more or less subconsciously avoided. Third is the effect of drugs. This may take the form of temporary residual paralysis after spinal anesthesia, but usually it is due to the administration of opiates which may tighten the internal sphincter or make the patient unaware of fullness of the bladder until it is overstretched; antispasmodics may lessen the contractility of the detrusor muscle, especially if opiates are given at the same time.

Some surgeons are loath to have their patients catheterized until prolonged, painful distention of the bladder has rendered the situation intolerable. They maintain that avoidance of catheterization is avoidance of infection and remain blissfully unaware of the havoc that prolonged painful distention of the bladder ordinarily produces, especially when supplemented by the patient's futile efforts to void. As Cabot long ago pointed out, prolonged distention of the bladder injures it and makes it a ready victim of infection. Experimentally,[1] such distention causes mucosal and submucosal hemorrhages and thus produces devitalized tissue which is an ideal culture medium for bacteria. Unfortunately, to this situation is added loss of tone by the detrusor as the direct result of the same injury. This has long been evident from the experience of patients with hitherto symptomless obstruction at the vesical neck who, either because of indulgence in alcohol or because of a long ride in an automobile, hold their urine too long, are then unable to let it go, and develop persistent retention. This crude clinical observation has recently been proved experimentally in a striking manner by Kirwin and Hawes. They had six ambulatory young men entirely free from lesions of the urinary tract hold their urine as long as possible. After they had finally voided, they were catheterized. All had residual urine, which

greatly improved. He was discharged on Feb. 21, 1939, twelve days after admission. At this time his neurologic examination was normal. He was seen again two months later, at which time he was free of symptoms and no abnormalities were detected.

DISCUSSION

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empty bottle beneath the bed. Thus the bladder is kept empty, avoiding both trauma and stagnation of urine, and it can be irrigated by releasing a clamp. This obviates the contamination which is inevitably introduced from without when unsterile equipment is used or when the catheter is irrigated by hand by any but the most skilled assistants. Stalker and Schulte have recently shown that infection with the inlying catheter in postoperative patients may be obviated in one-half and minimized in the other half of patients with inlying catheters by giving 5 gr. of sulfanilamide three times daily, producing a concentration of 25 mg. of sulfanilamide per 100 c.c. of urine.

Many surgeons will follow such a regime only to undo its good effects by premature removal of the catheter, or by forgetting the bladder as soon as the catheter is out. It should be left in place until the patient is gaining strength and is able to move about freely in bed. After the catheter has been removed, the residual urine should be measured in ten to twelve hours, or less if the patient experiences any discomfort, since overdistention of the bladder may prove troublesome even at this time. If the residual exceeds 75 to 100 c.c. or if urination is difficult, the catheter should be reinserted and removed every day until residual urine is absent and urination is easy.

If the bladder is emptied completely and spontaneously, the residual should again be measured in twenty-four hours to make certain that the ability to empty it has been retained. This is especially important in the elderly male who may have had a low-grade obstruction at the vesical neck with neither palpable enlargement of the prostate nor symptoms; this situation occurs not infrequently with contracture of the vesical neck or enlargement of the median lobe when the detrusor is hypertrophied. Such a patient may respond to any stress or strain with a retention of urine which, if at all neglected, will become permanent and necessitate operation.

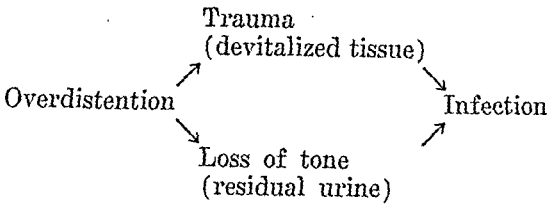
A few patients who do not empty the bladder completely after removal of the catheter may be aided to do so by the administration of pilocarpine or mecholyl (to stimulate the detrusor through the parasympathetics) and by being taught to void as much as possible, rest a moment or two, and then repeat the effort one or more times.

If residual urine persists despite these measures after the patient is out of bed, cystoscopy is clearly indicated to determine the cause. It should be done by one qualified to recognize minor obstructions in either sex.

The regime outlined above is a simple one, but its meticulous application will save both patient and surgeon a very great deal of worry and discomfort and will shorten many a convalescence. As much more could be said about the management of neurogenic vesical dysfunction (or cord bladder if you prefer). Suffice it to say here that, in those dysfunctions due to injury of the spinal cord, an attempt should be made

ranged from 70 to 365 c.c., with an average of 170 c.c. Remembering that these were robust, ambulatory men, it is easy to understand the frequency of urinary retention in sick postoperative patients who must void lying down despite painful incisions and the inhibitory effects of drugs.

The situation may be depicted thus:



This unfortunate situation is readily prevented (but much less readily cured once it has appeared) by proper attention to the bladder following operation. Account must be taken of the fluid intake. A patient who receives 3,000 c.c. of fluid per day will ordinarily put out at least one-half that same amount of urine. Since the average bladder will be painfully distended by about 500 c.c. of urine, the bladder must be emptied at least three, and often four, times daily to avoid overstretching. Also, fluids given intravenously may accumulate very rapidly in the bladder, at the rate of 500 c.c. an hour, or even more. Yet many a surgeon will order a liter of fluid intravenously immediately after operation, caution the house staff and nurses against catheterization unless absolutely unavoidable, and write an order to "catheterize every eight hours if necessary." An hour later the bladder is full; but, if the order is taken literally, seven hours will elapse before relief comes unless someone intervenes. Infection follows catheterization; the poor, innocent catheter (and the intern or nurse who wielded it) gets the blame which obviously attaches to the surgeon who, in the words of Cabot, "prepared the soil." Next time, he is even more determined to avoid catheterization.

Everyone is familiar with the dodges used to evoke urination, such as pouring warm water over the genitals or hand, applying a hot-water bag to the suprapubic area, running water within the patient's hearing, etc. These are not objectionable in themselves, and not infrequently are followed by micturition. They should be used only until distention becomes mildly uncomfortable without being painful, when a catheter should at once be employed. The gentle, aseptic passage of a small (No. 14 French), well-lubricated, soft rubber catheter does no harm unless the bladder has been previously damaged. If catheterization has to be repeated more than once or twice, the catheter should be tied in and connected through one arm of a sterile glass Y-tube and rubber tubing to a sterile reservoir hung at the bedside and containing sterile fluid (either water or a mild antiseptic); the other arm goes to a sterile

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

THE SURGICAL TREATMENT OF GASTRIC AND DUODENAL ULCER

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WHILE there has been little recent advance in determining the cause of ulcer of the stomach or duodenum, there has developed during the last few years a better correlation of medical and surgical thought resulting in a more uniform treatment of the disease. Close cooperation now exists among internist, surgeon, and roentgenologist, both for diagnosis as well as treatment and subsequent care of the patient.

In contrast to fifteen years ago when over one-half of the patients with ulcer were treated by surgical measures, surgery is now confined to those instances in which complications occur during medical treatment. This then limits the number of surgically treated cases to 5 to 10 per cent of duodenal ulcers and approximately 20 per cent of gastric ulcers.[3, 126] With improving methods of medical treatment, such as aluminum hydroxide therapy, the number of patients requiring surgery may be even further decreased.

At present it is generally agreed that the indications for surgery in the treatment of ulcer should be limited to perforation, pyloric obstruction, certain instances of profuse hemorrhage, intractable pain not controlled by medical treatment, and a suspicion of malignancy. Although these general indications are widely accepted, there is still a diversity of opinion as to the type of operation which should be carried out and, except for perforation, the time when it should be performed. An attempt will be made to summarize the trend of surgical opinion over the five-year period, 1934-1938, in regard to the treatment of gastric and duodenal ulcers by reviewing the various methods of surgical treatment employed and by evaluating their results.

PERFORATION

There is usually little difficulty in the diagnosis of acute perforation. To the classical symptoms of acute epigastric pain, boardlike rigidity, localized epigastric tenderness with the usual concomitant general symptoms, such as increased pulse rate, nausea, perhaps vomiting, etc., may be added the obliteration of liver dullness due to free gas under the diaphragm and referred shoulder girdle pain from stimulation of the

first to empty the bladder by the Credé maneuver sufficiently often to prevent overdistention. If this fails or is impractical, an inlying catheter with an irrigator, such as that of Munro and Hahn, permitting tidal irrigation, should be used, since this is a very satisfactory means of minimizing or preventing damage to the urinary tract. If, after improvement of the spinal cord is complete, it becomes evident that the innervation of the bladder is permanently destroyed, cystostomy should be done, since it is much easier to maintain than an inlying catheter and is free from the risk of periurethritis, prostatitis, and epididymitis. Should recovery of the cord then occur unexpectedly, the bladder has been preserved intact and will resume its function if the tube is removed.

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There is no general agreement as to the type of anesthesia which should be used or to the superiority of any one type. However, local infiltration anesthesia is usually unsatisfactory because of the general distress of the patient and the marked abdominal rigidity. It is our custom to administer nitrous oxide-oxygen and ether. Fallis favors spinal anesthesia because he found a greatly reduced mortality rate in a series of cases in which spinal anesthesia was used in contrast to a second group in which general anesthesia was used. But each surgeon should use the anesthesia to which he is most accustomed.

Perforation is the one complication of gastric or duodenal ulcer in which immediate surgery is unquestioned. There are, however, various opinions concerning the technique of closing the perforation, the inclusion of additional surgical procedures, and the advisability of drainage.

A variety of incisions has been advocated for exposure of an acute perforation. Amendola describes an easy approach, a small incision starting about one inch below the xiphoid and extending downward parallel to the costal margin for a distance of about three and one-half inches. He cites the several advantages of this exposure to be as follows: straining under anesthesia does not interfere with the exposure; bleeding is minimal; greater exposure can easily be obtained by extension at either end; direct exposure of the site of perforation is attained in about 95 per cent of the cases, about the proportion which occurs in the first part of the duodenum on its anterior-superior surface; subsequent hernia is less likely because the liver protects the undersurface of the wound; this small incision can be easily closed and another made if the diagnosis should prove incorrect; the incidence of pulmonary complications is reduced because full respiratory excursion can be made without pain; and finally, it is possible to get patients out of bed sooner than the use of the usual liberal midline or right rectus incision permits. Although the approach described by Amendola is satisfactory, the incision must be large enough to permit adequate inspection of the duodenum and stomach to rule out the possibility of a second perforation. Regardless of how obvious the perforation may be, James and Matheson have emphasized the possibility of a coexistent second perforation. Schilling, of Oslo, advocates a primary incision in the right iliac fossa as well as the usual incision for closure of the perforation. A lavage is carried out through both incisions followed by closure without drainage. With this procedure he is able to report a mortality rate of 2.8 per cent where operation is performed within six hours of the time of perforation and 7.4 per cent when performed within twelve hours. The general adoption of this procedure would seem undesirable since its use might cause a spread of infection.

To prove the presence of air within the peritoneal cavity, it is helpful to fill the wound with saline solution and note the presence of air bubbles at the time of opening the peritoneal cavity. There is general agreement in the literature that as much as possible of the intraperitoneal fluid and

phrenic nerve. Helpful diagnostic information may also be obtained by a roentgenogram taken with the patient upright to demonstrate free air under the diaphragm. S. E. Johnson in this way found evidence of pneumoperitoneum in 83 per cent of forty-two cases. Paine and Rigler have demonstrated from experimental observations that as little as 5 c.c. of air within the peritoneal cavity can be shown by x-ray. It should be remembered, however, that pneumoperitoneum does not always occur and therefore the surgeon should not necessarily refrain from operating in its absence. Moreover, unless a roentgenogram can be taken immediately, operation should not be delayed to prove or disprove the presence of a pneumoperitoneum, since it has been so clearly shown that the mortality rate rises in almost direct proportion to the length of time elapsing between perforation and time of closure. Singer has described the syndrome of intermittent perforation.

Perforation occurs most frequently in men between 30 and 50 years of age.[27] However, all ages from infancy to 82 years are recorded in the literature, the latter being a case of perforated gastric ulcer reported by Sandell. The preponderance of perforations occurring in males is further emphasized by the report of Eliason and Ebeling of seventy-four perforations in which only one occurred in a woman.

Probstein, Gray, and Wheeler observe a high diastase in those occasional ulcers which perforate posteriorly into the pancreas. From this they conclude that a low diastase determination rules out acute pancreatitis as well as a perforation involving the pancreas as the cause of the acute abdominal symptoms.

The preoperative preparation of the patient is often as important as the technical steps of closure, especially in late perforation. As for any acute abdominal emergency, the fluid balance must be properly adjusted by the administration of parenteral saline and dextrose given preferably by vein. Also, it is desirable to insert a nasal tube and institute constant gastric suction as soon as possible. This empties the stomach and prevents or limits the further escape of gastric or duodenal contents into the peritoneal cavity until the perforation is closed. Moreover, vomiting during or after operation is avoided by maintaining the suction until the edema about the pylorus has subsided and patency is re-established. The use of constant gastric suction is probably the most important addition to the treatment of gastric cases in the last five years.

Nisbet calls attention to Baker's suggestion of administering methylene blue by mouth just before operation. Two or three ounces of a 2 per cent methylene blue solution are given orally after the preoperative medication and before the patient enters the operating room. The escape of the dye through the perforation aids, he believes, in its localization, thereby saving time and eliminating a good deal of manipulation. At the same time it helps to define the size of the perforation. Moreover in some instances the staining by the dye may settle the question as to whether or not the hole has already been sufficiently well sealed off.

resection may be a poor choice of operation because it does not guarantee the patient against recurrent ulceration of the duodenum.

Opinion concerning the advisability of drainage following closure of the perforation is about equally divided. There are those on the one hand who believe drainage is a lifesaving procedure and those on the other who believe that it not only is unnecessary but adds definitely to the mortality rate. Eliason and North, for example, advocate drainage routinely at the site of perforation. They bring the drain out through a stab wound and place a second drain laterally between the liver and diaphragm if there is contamination at this site. In addition a suprapubic drain may be inserted. It is their impression that the lives saved by drainage outweigh the damage it may do. They were able to grow bacteria in 80 per cent of the cases in which a culture was taken. Fallis likewise recommends routine drainage since the principal cause of death from perforation is peritonitis, and believes that it may be a lifesaving procedure. Morrison advocates drainage and employed it in 178 out of 200 cases. On the other hand, McCreery, Sallick, Trout, and others believe that drainage is unnecessary. Certainly this problem cannot be solved by an analysis of the mortality figures of the two schools of thought, since in each instance these range from approximately 10 to 22 per cent. It would seem that drainage may be safely omitted in early perforation when there is little evidence of gross contamination of the peritoneal cavity. Drainage is advisable in late perforation or in the presence of extensive soiling from the escape of gastrointestinal contents into the peritoneal cavity.

The management of late cases of perforation demands special attention. Occasionally in patients in extremely poor condition who seek relief twenty-four or more hours after perforation, better results may be obtained by attempting to restore electrolyte balance and by maintaining constant gastric suction. Under this treatment the perforation may seal off and recovery may follow despite what at first appeared to be a hopeless outlook.

From a series of experiments in animals Bergh, Bowers, and Wangensteen are able to show a mortality rate of 86.7 per cent from peritonitis when a stomach containing food is perforated compared to 6.9 per cent for an empty stomach. These experimental observations are consistent with the clinical findings. Furthermore, they report a mortality of 81.2 per cent for experimental perforation of the duodenum in fasting animals in contrast to only 6.9 per cent mortality for similar gastric perforations. Since few organisms are present in the duodenum of fasting animals, the high mortality must be associated with injurious effects produced by bile and pancreatic juice. This confirms the finding of Blalock that gastric juice is less harmful than duodenal juice. He finds in studying the effect of the escape of large amounts of bile, pancreatic, gastric, and duodenal juices into the

particles of food should be removed by aspiration. It is desirable, moreover, to avoid injuring the already insulted serosa by the introduction of too many packs into the peritoneal cavity.

A wide diversity of opinion exists as to the proper management of the perforation itself. The majority of surgeons believe that the less done the better and that no more than simple closure of the perforation should be carried out. The recent literature clearly indicates that in the past there has been too much fear of obstructing the pylorus following closure alone. With the use of constant gastric suction it is now apparent that troublesome acute postoperative obstruction of the pylorus is infrequently encountered despite the fact that at the time of operation the duodenum may appear to be occluded. Graham[26] prefers to close the perforation with three chromic catgut sutures, one introduced at its upper margin, one in the middle, and one at the lower margin. These are tied loosely over a tag of omentum or a free omental graft. The use of omentum in sealing off the perforation has been widely adopted. Gatch and Owen advocate an excellent method of closure, using normal flexible gastric and duodenal wall well beyond the site of induration. They recommend that several silk sutures be introduced into the gastric wall about one or two inches proximal to the pylorus and well distal to the ulcer in the duodenum, where a firm hold can be obtained in relatively normal intestinal muscularis. None of the sutures is tied until all have been properly placed. The suture line must seal off both above and below the point of perforation, and in addition the omentum may be anchored up over the suture line. It is not necessary to close the perforation with two or three layers of sutures. However, this method cannot be used to close perforations complicated by supraduodenal abscesses. Despite the fact that this technique would appear to occlude the duodenum completely, such has not been proved to be the case. In only one patient in twenty was it necessary to perform a posterior gastroenterostomy later.

The general opinion in this country is that in the great majority of cases the addition of any procedure to that of simple closure in the long run will raise the mortality rate. Certain foreign surgeons, however, advocate radical resection for perforation. Judin, of Russia, for example, recommends resection in young persons and employs conservative operations only in the elderly or in those with advanced peritonitis. The Billroth I type of resection is usually the choice, with a few instances of the Polya-Balfour type of gastrojejunal anastomosis. He reports 331 resections for perforated ulcer, with a mortality of 7.8 per cent. It is often difficult to evaluate many of these mortality figures because only in the good risk patient with a very short duration of perforation are the more radical procedures done. Other sporadic reports advocate resection for perforation. For a time at the Peter Bent Brigham Hospital this principle was tried, but it was soon found that the mortality rate did not justify the procedure. Furthermore, a simple pylorectomy or Billroth I

x-ray. Benedict also emphasizes the value of gastroscopy in many cases of gastrointestinal hemorrhage.

Surgeons writing on the problem of the treatment of gastric or duodenal hemorrhage from ulcer invariably make a plea that they be consulted early and that the responsibility of deciding upon surgical therapy be divided equally between the surgeon and internist at the onset of the hemorrhage. By such cooperation it is hoped that a better decision as to the time for surgery, if it is indicated, can be made and that surgery will not be considered a final gesture to be employed only after the failure of medical treatment.

It has been repeatedly emphasized that surgery as a late treatment for the exsanguinated patient carries a high mortality, usually more than 30 per cent.[29] In the Peter Bent Brigham Hospital, Emery and Monroe conclude that the late results of surgical procedures in the treatment of hemorrhage are about the same as those following exacting medical treatment. They find the incidence of hemorrhage after all types of operations for a variety of indications, including hemorrhage, to be 17.4 per cent as compared to 19.3 per cent for a similar group after medical treatment alone.

Many writers point out that the mortality rate from bleeding is very low in youth and early middle age, but that it rises abruptly after the age of 45 years. Jankelson and Segal report a mortality rate of 5 per cent below the age of 40 years and 15 per cent above that age. Allen[2] states that duodenal ulcer treated conservatively rarely causes fatal bleeding under 50 years of age, but at the Massachusetts General Hospital there was a mortality of 33 per cent in patients over 50. Consequently, the teaching is becoming more widespread that bleeding from gastric or duodenal ulcer in patients beyond middle age is a much more serious complication than it is in the younger group and that early surgery must be considered if the inevitable high mortality rate is to be lowered.

That there exists an optimum time for surgery after the onset of bleeding and that surgery delayed beyond this point will result in a much higher mortality rate, regardless of the amount of blood given by transfusion, seems well established.[29] In patients seen forty-eight hours or longer after the initial massive hemorrhage, it is well to delay operation until recovery is complete. Massive gastric hemorrhage is not uncommon in women with an acute lesion of the mucous membrane, but unless there has been a previous history of ulcer, surgery is withheld. In young persons surgery may be withheld to see if, under medical treatment, the ulcer crater will entirely heal and the patient will remain symptom free. Otherwise, resection is, as a rule, wise after the patient has recovered from the acute blood loss. Surgery is indicated in patients having recurrent hemorrhage on adequate medical treatment regardless of age, since it has been emphasized that there is an abrupt rise in mortality following the second hemorrhage.[33]

peritoneal cavity that infected pancreatic juice or a mixture of bile and pancreatic juice is more lethal than any single juice, particularly if it is sterile.

The late results following operation for perforation are reported by various authors. Cable finds only 19.5 per cent of the cases which could be classed as good or excellent six months to three and one-half years after simple closure. Lewisohn[69] reports a recurrence of symptoms in 39 per cent of his cases and emphasizes the apparent fallacy of the rather widespread belief that perforation cures the ulcer. Guthrie and Sharer, however, find that 95 per cent of their cases followed after simple closure of a perforation remained well, and they believe that perforation acts to some extent like cauterization. Eliason and Thigpen find 86.4 per cent symptom free after simple closure and 76.2 per cent after closure and posterior gastroenterostomy.

In the Peter Bent Brigham Hospital the patients with perforated ulcer receive strict medical treatment after operation and are maintained on this regimen for an indefinite period. It is indeed dangerous to imply to a patient that, since perforation has occurred, there is little need to worry about subsequent trouble from the ulcer.

HEMORRHAGE

The treatment of the complication of hemorrhage is far from uniform in regard to the advisability of surgery, the type of surgical procedure, and the best time for its performance. Goldman[34] and others emphasize the fact that too many physicians believe gross hemorrhage from an ulcer is rarely fatal and adopt a policy of watchful waiting. The danger inherent in this point of view is demonstrated by the mortality of 15 per cent in his series of 349 cases. Jankelson and Segal report a mortality of 10.5 per cent in 200 massive hemorrhages. It is apparent from a study of the literature that a definite percentage, ranging from 5 to 15 per cent, of cases of massive hemorrhage associated with ulcer terminates fatally in the hospital.

Various methods of medical treatment are recommended, usually based on bed rest, starvation, and sedation. However, Meulengracht advocates early feeding and on this basis reports the low mortality of 1.3 per cent in 368 consecutive cases. Satisfactory results are reported following the administration of aluminum hydroxide by nasal tube, as described by Woldman. However, it is too early to evaluate the effectiveness of the Meulengracht diet or the aluminum hydroxide method in lowering the number of bleeding cases which require surgery.

Schindler believes that gross hemorrhage is one of the most important indications for gastroscopy. As soon as possible after the patient has recovered sufficiently, x-ray examination and gastroscopy should be carried out. By gastroscopy the source of the hemorrhage may be revealed, such as that from tiny hemorrhagic erosions, small ulcerations in hypertrophic ulcerative gastritis, and similar lesions which are not shown by

gastroenterostomy. Allen[2] reports disappointing results in fifteen patients in whom the antrum was transected and a posterior gastroenterostomy was carried out. This type of procedure he abandoned in favor of radical resection with removal of one-third to two-thirds of the distal portion of the stomach as well as the ulcer-bearing portion of the duodenum when possible. He has carried out this operation without a fatality in thirty-eight consecutive cases of posterior wall duodenal ulcer with satisfactory results at the time of reporting.

Allen[2] also re-emphasizes the procedure previously described by him and Benedict for the operative removal of a posterior penetrating ulcer which is actually bleeding. He calls attention to the anastomotic blood supply involving the gastroduodenal artery, a vessel which is frequently involved in the massive hemorrhage. Since the gastroduodenal artery communicates with the pancreaticoduodenal and gastroepiploic arteries, it is necessary to ligate all three to control massive hemorrhage safely in the posterior penetrating ulcer. The stomach is divided between crushing clamps at the desired level, and the pylorus is reflected to the right, exposing the posterior surface of the duodenum, to obtain a good view of the area of erosion of the ulcer into the pancreas. When the patient is actually bleeding, the distal portion of the stomach is opened on its anterior surface between long clamps exposing the ulcer and permitting the surgeon to introduce his index finger into it for immediate control of the bleeding. If preferred, the ulcer may be packed, and the pack may be held in place by an assistant during the subsequent steps of the operation. This provides an opportunity for the surgeon to visualize adequately the papilla of Vater. The vessels entering the inflamed area are then ligated after careful consideration of the anastomotic blood supply. When the ulcer has eroded deeply into the pancreatic tissues, no effort is made to remove or cauterize the involved portion of the pancreas. The duodenal wall is freed beyond the point of ulceration, and the stump is closed in the usual fashion. In those instances in which the ulceration is so low on the duodenum that closure in the usual fashion might obstruct the papilla of Vater, the duodenum may be safely closed by approximating the serous coat of its anterior wall to the capsule of the pancreas. Another method of closure utilizes the remaining antrum which has been denuded of its mucosa. The approximated walls of the antrum cover the ulcerated area as well as close the duodenum. A Polya type of gastrojejunostomy is then carried out. Stab wound drainage may be instituted to the subhepatic space if the surgeon thinks there may have been injury to an accessory pancreatic duct.

Pfeiffer[88, 89] emphasizes the principle that the primary consideration at the time of surgery for bleeding ulcer is hemostasis, and not necessarily that of curing the ulcer. He advocates a gastroduodenotomy, which provides adequate exposure of the bleeding point. The point is then sealed off with a coagulating electrode or an encircling suture of chromic catgut placed through the tissues above and below. The overhanging edges of the ulcer may be mobilized and brought together with

In the preparation of these patients for surgery, adequate blood should be available for transfusion. As much as 3,600 c.c. of blood has been given by the drip method over a period of five days previous to the time of resection.[43] It is generally accepted that intravenous fluid should not be given because of the danger of increasing the blood pressure and initiating further bleeding. Such fluid as is necessary, other than blood, is given by hypodermoclysis to be taken up as needed. Blood transfusions should be given following the fall of the blood pressure to at least 70 mm. of mercury. There is no evidence that the giving of calcium and the various thromboplastic substances has any effect on the hemorrhage.

A Levine tube may be passed into the stomach by the nasal route, and the stomach may be emptied of its contents. Some believe that this is dangerous and may initiate further bleeding; also that the administration of epinephrine or astringents by stomach tube is without effect when the hemorrhage is severe.[33] The proponents of constant gastric suction believe that by aspirating saliva, gastric juice, and blood clot the stomach is put at rest, and that the strain of vomiting with possible renewal of hemorrhage is avoided. Should bleeding recur, it can be quickly detected by aspiration of the stomach contents and appropriate treatment can be carried out. It is advisable to leave this tube in place during operation and the early postoperative period.

The recent surgical literature tends to discredit posterior gastroenterostomy in the treatment of the bleeding case, although Walters[114] states that gastroenterostomy will protect the patient against recurrence of hemorrhage in 82 per cent of the cases, and, should hemorrhage recur, it is seldom of serious import. Westermann reports seventeen patients with bleeding ulcer on whom a gastroenterostomy was performed and who later developed recurrent hemorrhage. Lewisohn[68] believes that a posterior gastroenterostomy is absolutely futile in bleeding gastroduodenal ulcers. Hinton[44] states that thirteen of the 123 bleeding ulcer patients seen at Bellevue Hospital had a previous posterior gastroenterostomy. Many others believe that posterior gastroenterostomy does not protect the bleeding case permanently from a recurrent hemorrhage. According to Goldman,[34] thirty patients in his series had gross hemorrhage from an ulcer after gastroenterostomy. He advocates removal of the ulcer in addition to a subtotal gastrectomy after the method of Allen and Benedict.

With gastroenterostomy generally accepted as inadequate in the treatment of hemorrhage, there has been a trend toward radical gastric resection after the teaching of Finsterer. Finsterer[29] reports a mortality of 4.3 per cent for early resection in massive hemorrhage. However, this figure jumps to 32.7 per cent when operation is delayed by a trial of medical treatment. He insists that surgical therapy should be instituted within forty-eight hours of the initial massive hemorrhage.

About the same results are reported for the exclusion operation as for

sisting of alkaline therapy, antispasmodics, and aspiration will recover without surgery. It is only when retention of 40 per cent persists or recurs on adequate medical treatment that surgery is recommended.[126] In the presence of obstruction it is important that the surgeon take into consideration the adequacy of the previous medical treatment and make certain that the retention is a result of scarring or hypertrophy of the pylorus with impaired motor function. Persistent or recurrent obstruction is, therefore, a definite indication for surgery.

The ulcer patient with pyloric obstruction must be carefully prepared for surgery. These patients are usually undernourished, with imbalance of their electrolytes, vitamins, and protein metabolism. In addition, the dilated stomach may present many technical obstacles to surgery. McNealy and Lichtenstein point out that suturing may be difficult in the thickened, edematous walls of the stomach in these patients. Not only may the ordinary anatomical relations be so disturbed that the stoma may be incorrectly placed, but the outlet may be reduced markedly in size when the elongated fibers of the stomach have had an opportunity to shorten after operation. They recommend that, after the stomach has been washed out to remove undigested food, the patient be placed on constant gastric suction with a modified Wangensteen apparatus and that a so-called pyloric balance chart be maintained. This balance chart is designed to indicate the ability of the stomach to empty its contents into the duodenum. A negative balance implies that the amount of gastric contents which can be aspirated exceeds the amount given by mouth, and a positive pyloric balance that the amount of gastric contents which can be aspirated is less than the amount given by mouth. In the presence of a positive balance it may be assumed that the stomach is able to evacuate some of its contents. This method is employed in cases of malignant obstruction as well, and in these cases 60 to 80 minims of dilute hydrochloric acid are administered three times a day. Special attention should be given to the patient with obstruction suffering from alkalosis and nitrogen retention. The use of aluminum hydroxide in lieu of the usual Sippy powders should avoid this complication and better prepare the patient for surgery. If the serum protein levels are lowered, a transfusion should be given preoperatively. Electrolytic balance is maintained by the intravenous administration of 5 per cent dextrose in isotonic saline solution. Gastric lavage is carried out the night before and the morning of operation, and the patient is maintained on constant gastric suction during and after the operation.

The most enthusiastic supporters of radical resection agree that posterior gastroenterostomy has a major place in the treatment of pyloric obstruction, but even here the operation should be limited to those patients with definite scarring of the pylorus, impaired motor function, and low acid values. Such patients are usually middle-aged or elderly. However, gastroenterostomy should not be carried out in young persons or in those with high acid values. Newburger reports that gastroenter-

sutures. Small radiating incisions may be of advantage in instances of large excavated ulcer. This, he believes, is not as shocking a procedure as resection and offers a low mortality rate with a good chance of cure. Moreover, it presents no handicap to radical resection should such become necessary later. Lahey and Marshall advise the use of four crossed mattress sutures of silk passed through the periphery of the ulcer which, when tied, control the bleeding. They prefer silk to catgut sutures because of the danger of digestion of the catgut resulting in recurrent bleeding. Many, however, believe it is unwise to risk the control of a bleeding point to transfixing sutures of chromic catgut or silk passed through the bed of the ulcer. Hinton[45] points out that the eroded artery may be anywhere from one-half to three-fourths of an inch from the duodenal wall. Accordingly, the sutures applied to control the bleeding in the bed of the ulcer of necessity must be applied rather deeply and blindly.

The consensus of opinion then in the treatment of bleeding duodenal ulcer is to control the bleeding point in the poor risk patient and to keep in mind that hemostasis and not necessarily the permanent cure of the ulcer is the immediate goal. However, whenever the general condition of the patient permits, a sufficient amount of the stomach may be removed to reduce the secretion of acid as well as to remove the ulcer-bearing area. Following this some type of gastrojejunal anastomosis is carried out. Ligation of the coronary arteries alone is considered insufficient to control the bleeding. Because of the danger of malignancy in gastric ulcer, excision of a liberal edge is advocated not only to control the bleeding but to permit adequate microscopic examination. Even the opponents of gastroenterostomy in the treatment of duodenal ulcer believe that it may have a place in the treatment of gastric ulcer.

OBSTRUCTION

Gastric retention as the result of edema, hypertrophy, spasm, or scarring of the pylorus is a common complication of both gastric and duodenal ulcers. Kruse finds 51 per cent of ulcers showing some obstructive characteristics. Despite its clinical frequency, Monroe and Emery find that obstruction as a complication of ulcer causes less than one-twentieth of the deaths in comparison with perforation which causes one-third and hemorrhage, one-fourth. In 120 cases with ulcer Portis and Jaffe report stenosis the principal lesion at necropsy in 11.6 per cent of ulcers of the stomach and 4.2 per cent of ulcers of the duodenum.

It is emphasized that gastric ulcer some distance from the pylorus may produce pyloric spasm with gastric retention and may make it difficult for the roentgenologist to distinguish between gastric and duodenal ulcer. A retention of 100 per cent at one examination is not an indication for surgery. It has been pointed out by Emery and Monroe and others that the great majority of such patients if put on strict medical treatment con-

Treitz to avoid the possibility of a gastrojejunocolic fistula if ulceration should occur postoperatively. McCaughan and Coughlin stress the importance of making the opening in the mesocolon to the left of the middle colic artery to avoid obstruction between it and the superior mesenteric vessels. When the stomach is dilated, the loop of jejunum must be longer than usual and the stoma must be made larger to insure satisfactory function upon the return of the stomach to a normal size.

The Finney pyloroplasty is used by Graham[38] occasionally as well as posterior gastroenterostomy. He also uses the Finney pyloroplasty in elderly patients if there is pyloric stenosis, low free hydrochloric acid, and no massive hematemesis. From his experiments Dragstedt concludes that gastroduodenostomy with a large stoma or pyloroplasty is preferable to gastrojejunostomy in the presence of retention. Clute and Sprague advocate gastroduodenostomy for the relief of pyloric stenosis and report seven satisfactory cases. They describe the technical steps of properly freeing the lateral wall of the duodenum to avoid postoperative obstruction from rotation of the duodenal loop.

One of the major problems in the treatment of pyloric obstruction from ulcer is to determine when surgery is advisable. It is generally agreed that immediate surgery should not be recommended initially even if the patient's symptoms and x-ray findings indicate complete pyloric obstruction, because remarkable improvement and frequent avoidance of surgery may follow gastric lavage and nightly aspiration, bed rest, and strict medical management. At the end of this period of treatment, even if the obstruction is not overcome, the patient is a much better risk for surgery, due to the restoration of proteins, vitamins, and calories and the equalization of the electrolytic balance. If troublesome obstruction persists, it is generally agreed that gastroenterostomy is the ideal type of operation except in young persons or in those with high acid values. Gastroenterostomy may also be advisable when technical difficulties prevent resection or when the patient is a very poor risk. A discussion of the end results of gastroenterostomy is included under the heading of jejunal ulcer.

INTRACTABLE TO ADEQUATE MEDICAL TREATMENT

This comprises a large miscellaneous group of patients who continue to have pain or discomfort despite adequate medical therapy. It is assumed that these patients are the severe clinical types which have failed to respond to an ideal form of medical treatment. They frequently have high acid values, or may be classed as cases of hypersecretion. It is in this group that the argument of conservative versus radical operative procedures is most heated. In fact there are as many able opponents for conservative measures, such as posterior gastroenterostomy, as for radical subtotal resection, making it difficult in reviewing the literature to evaluate or understand such extreme divergence in surgical opinion. It is apparent that the surgeon must be prepared to carry out a variety of

ostomies performed in patients below the age of 30 years are usually failures. Marshall and Kiefer believe that gastroenterostomy has a place in the treatment of obstruction because of its low mortality rate and the smooth convalescence it affords patients past middle age who have low acid values and considerable cicatrical pyloric obstruction. Nicolaysen states that gastroenterostomy should be the method of choice in patients 45 years of age and older and that further it is indicated in pyloric stenosis with large retention and induration of the stomach irrespective of the age. Others are not in accord with the use of short-circuiting procedures regardless of the age of the patient, believing that it is dangerous in the young because of recurrent jejunal ulceration. Crile and Crile, Jr., report that 87.5 per cent of the patients having gastroenterostomy for obstruction are relieved of their symptoms as compared to only 60 per cent of twenty cases for pain. Graham[35] points out that in the presence of obstruction surgery should not be carried out until a gastric analysis has been done in order to determine the proper operative procedure. He favors gastroenterostomy for patients with a scarred pylorus and low hydrochloric acid values and for elderly patients with penetrating, nonstenosing ulcers without obstruction but with low free acid values. All other patients should be submitted to subtotal gastrectomy. Eggers finds that 90 per cent of his patients having a gastroenterostomy are relieved and that the mortality is 4.1 per cent; Truesdale that 18 per cent are not relieved and in 185 cases the mortality is 4.9 per cent. Graham[35] reports 89 gastroenterostomies with a mortality of 3.4 per cent; Allen and Welch 101 with a mortality of 7.9 per cent. These reports no doubt include many cases where the indication for surgery was one of the commonly accepted complications other than pyloric obstruction.

A reduction in the gastric acidity following posterior gastroenterostomy has been shown by Walters[115] to occur in 30 to 50 per cent of the cases. This is in contrast to the observation made by Holman and Sandusky, who found that the acid was not altered in 92 per cent of seventy-five patients and that the postoperative titratable acidity could not be used as the prognostic criterion of the results. Tomoda and Aramaki find that there was no uniformity in the acidity in thirty-two cases of gastroenterostomy, and conclude that the determination of the acid values alone in the stomach which has been operated upon is worthless in estimating the success or failure of a given operation.

Certain technical details of gastroenterostomy were recently emphasized. Kogut and Stein report two cases of gastroileostomy which promptly developed severe symptoms. This can be avoided by a clear visualization of the ligament of Treitz just before the jejunal loop is brought up to the stomach. Lahey and Swinton emphasize that in making a gastroenterostomy the opening in the mesocolon should be as far away from the transverse colon as possible and near the ligament of

The immediate preoperative care involves gastric lavage with a large caliber tube until clear fluid is returned. This is repeated on the morning of operation. When a high resection is anticipated, the Levine tube may be left in place to permit removal of gastric secretions during the progress of the operation, thus lessening the chance of soiling the field when the anastomosis is carried out. Fluid balance is corrected by the subcutaneous or intravenous administration of 5 per cent dextrose in isotonic saline solution if there has been retention. Otherwise the patient is encouraged to drink as much fluid as possible the day and night before operation. Some surgeons prefer to administer 500 c.c. of citrated blood during operation.

Various types of anesthesia are recommended. In the poor risk patient novocaine infiltration anesthesia fortified with a sufficient preliminary dosage of a suitable sedative is advisable. Finsterer prefers a supplementary splanchnic infiltration as well. Spinal anesthesia is finding greater favor in this country, especially with the use of drugs giving a prolonged effect. Sise believes that in most instances spinal anesthesia with nupercaine or pontocaine is satisfactory. The proper selection of anesthesia, he believes, plays a vital role in lowering the mortality rate. He reports a marked reduction of the mortality rate for gastric resection for ulcer when nupercaine spinal anesthesia is used: nupercaine spinal, 8.4 per cent mortality; combined anesthetics, intratracheal, 15.4 per cent; novocaine spinal and ether, 25 per cent. Nitrous oxide-oxygen and ether administered by an intratracheal method are also advocated. The intratracheal method is indicated especially for very high resections involving manipulation about the esophagus. In each instance the choice of the anesthesia must depend upon the condition of the individual patient and the surgeon's personal experience with the facilities at his command.

Each of the various types and methods of resection has its advocates. Gastroduodenostomy after the Billroth I method would appear to be the most physiologic type of operation. Experimental evidence supports this view. Horsley[49] prefers this operation with anastomosis of the duodenum to the lesser curvature. In performing this resection he does not hesitate to incise the anterior wall of the duodenum to enlarge its lumen and facilitate end-to-end anastomosis with the stomach. Jaeger also believes the Billroth I is the procedure of choice over gastroenterostomy. Jonsson finds the late results of Billroth I operation satisfactory in 94.5 per cent of his cases. Von Haberer advocates the use of the Billroth I procedure, and Steinberg recommends its use under certain conditions. Others have pointed out that the Billroth I operation has only a limited use and that it is followed by a high incidence of recurrent duodenal ulceration.[37] A recent review of a series of Billroth I operations at the Peter Bent Brigham Hospital shows this high incidence of recurrent duodenal ulceration, and for that reason the operation is no longer advocated in that clinic. Walters[115] believes that recurrence of

operations in the treatment of the ulcer depending upon the individual case. All too frequently in the reviewer's opinion there is a tendency to fall into the routine of a particular operation without sufficient consideration of the various factors involved. There is too great a tendency to be always radical or always conservative without suitable application of the various technical procedures available.

In skilled hands the mortality rate of resection has been markedly reduced and in recent years more nearly approaches that of posterior gastroenterostomy. Graham[35] reports a mortality in 140 subtotal gastrectomies of 3.8 per cent; Finsterer, a mortality in 920 resections for duodenal ulcer of 3.4 per cent with 94.6 per cent reported as cured; Cutler, a mortality of 9.3 per cent for resection with 3 per cent poor results; Lahey and Marshall, 130 subtotal gastrectomies with a mortality of 18 per cent and evidence of recurrent jejunal ulcer in 7 per cent. The majority of the reports include both gastric and duodenal ulcer.

But before any type of operation for gastric resection is attempted, the patient should receive adequate preoperative preparation. This may be varied somewhat depending upon the nutrition of the patient and the degree of pyloric obstruction. The factor of marked retention has been discussed under gastroenterostomy, with special reference to the pyloric balance sheet. Cutler and Zollinger advocate the substitution of a high caloric diet for the rigid ulcer regimen as a preparation for the postoperative period of limited caloric intake. But should the nutrition of the patient be seriously impaired, a jejunostomy for feeding purposes may be indicated before the primary gastric operation. Studley reports the interesting observation that, if patients lose 20 per cent of their preoperative weight, there is a postoperative mortality of 33 per cent in contrast to a mortality of 3.5 per cent in those patients who lose less weight and are in better general condition prior to operation. Since wound healing is encouraged by the administration of adequate amounts of vitamin C, patients receiving modern medical therapy should have proper vitamin replacement during their preoperative treatment. It is well established that free hydrochloric acid in the gastric juice has a sterilizing effect on the stomach contents with a lower incidence of postoperative infection. Moreover, it has been shown that this beneficial sterilizing effect is present even in the presence of low free acid values.[102] Alkaline therapy, therefore, may be withheld a few days before operation to permit sterilizing of the gastric contents by the return of high acid values.[72] In cases of preoperative hemorrhage, secondary anemia, or when an extensive procedure is anticipated, such as a radical resection, donors should be available for transfusion. The high incidence of pulmonary complications associated with upper abdominal surgery makes it imperative that elective gastric operations be carried out in a normal range of vital capacity and in the absence of respiratory infection.

conservative procedure. Radical resection should not be attempted in poor risk patients or where technical difficulties make it hazardous. It is generally agreed that even after a radical resection the patient must follow a careful medical regimen for an indefinite period.

GASTRIC ULCER

Although a far greater number of patients suffer from duodenal ulcer than from gastric ulcer, the percentage of the latter group coming to surgery is much higher. This is due to the fact that the problem in the treatment of gastric ulcer is to rule out the possibility of malignancy and to make certain that early eradication is undertaken if the location or progress of the lesion is suspicious; while, in the satisfactory treatment of duodenal ulcer, the problem is one of control of the acid factor.

There has long been argument as to whether gastric ulcers undergo malignant change. Hinton and Trubek are of the opinion that once a gastric ulcer always a gastric ulcer, although it may be difficult to tell the difference between a benign lesion and an early ulcerating carcinoma. It is their opinion that there is no conclusive evidence that gastric ulcer is a forerunner of gastric carcinoma. In contrast Chang believes that 5 per cent of gastric ulcers show malignant change, and Howze believes that cancer develops in about 10 per cent of all cases of gastric ulcer. Dible places the incidence of carcinoma at 5 to 6 per cent; Ransom, at 5 per cent; von Haberer, at about 9 per cent. On the other hand, Klein believes that if malignant degeneration occurs at all it is extremely rare and that this possibility is an insufficient indication for early radical surgery and removal of a gastric ulcer. Indeed the mortality rate from promiscuous gastric resection would be far greater than that from malignancy. Bloomfield believes that the only practical attitude to adopt is to regard small, apparently innocent gastric ulcers as benign until evidence to the contrary is weighty enough to arouse suspicion and to accept the fact that a certain number of unavoidable tragedies will occur. It is impossible to determine by clinical observation the early malignant changes in an apparently benign gastric ulcer. However, Schindler, in observing 66 patients with gastric ulcer by gastroscopy, was able to differentiate between benign and malignant ulcers of the lesser curvature and determine the source of hemorrhage, and thus to give invaluable aid to the clinician. In studying a large number of perforations associated with carcinoma, McNealy and Hedin suggest biopsy of the gastric perforation, believing that in this way an early case of carcinoma occasionally may be encountered.

The surgeon should be influenced by the location of the gastric ulcer because of the frequency of malignancy in certain areas. Gastric ulcers within one inch of the pylorus should be considered malignant until proved otherwise. Early surgery should be advised or rigid medical

ulceration after the Billroth I operation is much greater than after the Polya resection, even when the antrum has been removed. However, the Billroth I operation may be used if there is anacidity or very low acid values; otherwise some modification of the Billroth II operation, such as the Polya, may be used, although the Finsterer-Hofmeister modification is gaining more and more in general use.

There has been very little actual improvement in the technical steps of carrying out gastric resection. Lahey and Marshall endorse the use of the dePetz sewing clamp, and Graham,[37] of Toronto, and others use the Schoemaker clamp. Clute has devised a modification of the Furniss clamp which permits it to be inserted from either side, simplifying insertion of the pin and closure of the duodenal stump.

There appears to be a tendency to use a long loop of jejunum brought up anterior to the transverse colon. Since experimental evidence shows a decreased resistance to hydrochloric acid from the duodenum downward, the incidence of jejunal ulceration should increase when long jejunal loops are used in the anastomosis. If an anterior loop is used, an enteroenterostomy should not be done because of the high incidence of recurrent gastrojejunal ulceration. Some prefer to make a retrocolic, isoperistaltic anastomosis.[124] Connell recommends a V-shaped excision of a large portion of the fundus to decrease the acid-bearing surface. Cutler and Zollinger recommend an all-silk technique for gastric resection. Schindler, on the other hand, has recorded that, whenever a silk suture is found hanging free in the gastric cavity by gastroscopy, reoperation is indicated because of the associated recurrent ulceration and adjacent gastritis. Paolucci refutes this in a group of experiments on dogs, concluding that there is no relation between postoperative duodenal ulcer and a silk thread suture. Lahey[62] also in writing on jejunal ulcer states that linen or silk is not the true offender but is merely an innocent bystander in the formation of jejunal ulceration.

The number of patients requiring subtotal gastrectomy because of failure to respond to adequate medical treatment is gradually decreasing. This is due not only to improvement in the medical treatment afforded the patient with ulcer but to recognition of the fact that subtotal resection is not as effective in preventing subsequent difficulties as was originally hoped. Furthermore, late results from the more conservative surgical measures, such as gastroenterostomy, are satisfactory in the experience of many. The surgeon should not rigidly adhere to any one type of surgical procedure but should let his choice depend upon the history and general condition of the patient, the laboratory findings, and the findings at the time of operation. If he deems resection advisable, he should not be content with less than radical removal of a large portion of the acid-bearing surface of the stomach. However, the surgeon must have sufficient experience to be reasonably assured that the mortality rate from resection will not be far above that of a more

of 207 patients subjected to Billroth I operation ten to seventeen years previously, finds 73 per cent good results, 20 per cent fair results, and 7 per cent poor results; for the Billroth II operation, 76 per cent good results, 15 per cent fair results, and 5 per cent poor results. In his series the Billroth II operation gives slightly better results. He mentions, however, that at that period he did not remove as much stomach as is now advocated or the results might have been much better.

Horsley[50] reports ulcers occurring directly on the pyloric sphincter, a location present only in about 3 to 4 per cent of the cases of gastric ulcer. On these twelve cases a Billroth I type of operation was carried out in all instances.

It is apparent that every gastric ulcer should be considered potentially malignant regardless of the age of the patient, the findings by gastric analysis, or early clinical improvement. All patients with gastric ulcer must be subjected to strict medical management and frequent x-ray examination for an indefinite period until all symptoms and roentgenologic evidence entirely disappear. Large ulcerations, ulcers within one inch of the pylorus, those on the greater curvature, and those which do not respond to three or four weeks of medical treatment should be subjected to operation, together with those which perforate or bleed profusely. Small and benign appearing lesions may be excised and gastroenterostomy carried out. Billroth I resection is satisfactory for the small prepyloric lesion. However, if the indication for surgery is the possible chance that the ulcer is malignant, it is far safer to carry out a radical resection with removal of the regional lymph glands. The gastric ulcer, therefore, demands rigorous supervision with close cooperation among internist, roentgenologist, and surgeon.

JEJUNAL ULCER

Postoperative jejunal ulceration following gastroenterostomy or some type of Billroth II operation is an all too frequent complication of gastric surgery. It has been repeatedly emphasized in the literature that the best treatment of this serious complication is its prevention by more careful evaluation of the acid values and by more judicious selection of the initial operation. The incidence of jejunal ulceration is reported as from 2 to 24 per cent in patients having a gastroenterostomy.[65] Those in favor of conservative surgical treatment of gastric ulcer by the more general use of gastroenterostomy usually report an incidence of jejunal ulceration in patients observed after gastroenterostomy in the neighborhood of 3 per cent;[57, 116, 126] those in favor of radical treatment by resection usually report a much higher incidence. In the British Isles, Wright, in a collective inquiry into 2,734 patients having a gastroenterostomy, finds an incidence of jejunal ulcer in 8.49 per cent. Means believes that the occurrence of jejunal ulceration following gastroenterostomy is probably around 15 per cent, while Marshall and Kiefer are of

treatment with frequent roentgenologic examinations for an indefinite period regardless of apparent early clinical improvement. Very large ulcerations or ulcerations on the greater curvature should also be considered malignant. Scott urges that all gastric ulcers be resected which do not respond, under strict medical management, by diminution of symptoms the first week, complete disappearance of symptoms and absence of occult blood in stools the second week, and disappearance of the filling defect by fluoroscopy by the end of the third week. Walters[118] advocates surgery for gastric ulcer in patients who have had a hemorrhage when the x-ray shows a crater, when the lesion is producing pyloric obstruction, and when the ulcer is near the pylorus or on the greater curvature. The remaining indications for surgery are similar to those of duodenal ulcer; namely, perforation, persistent pain, obstruction, bleeding which does not respond to medical treatment, and stricture or hourglass contraction.

Once surgery is decided upon for gastric ulcer there is some difference of opinion as to the proper technical procedures to carry out. Balfour believes that excision and gastroenterostomy are ideal for the small gastric ulcer. It is his opinion that gastroenterostomy will heal gastric ulcers provided that there is no malignant change. Jejunal ulceration is not great after surgery for gastric ulcer, and there is a greater incidence of achlorhydria following operation for gastric ulcer than for duodenal ulcer. Walker believes that gastrojejunostomy for high gastric ulcer does not give good results. He prefers a Polya-Moynihan type of resection leaving the ulcer in situ. Segal and Scott also prefer the Polya-Moynihan type of resection which they carried out in thirty-four cases with relief in 82 per cent and a mortality of 11.8 per cent. The mortality in twenty-three cases operated upon by the senior author was only 4.3 per cent. It is their opinion that gastroenterostomy with local excision may give a low mortality, but that the morbidity is high, the total relief low, and the recurrence of malignancy when present almost invariable. Sénèque believes that gastrectomy instead of gastroenterostomy should be carried out for ulcers of the lesser curvature because of the danger of hemorrhage, the persistence of pain, and the possibility of neoplasm. Roholm and others find that a sleeve resection is unsatisfactory because of the frequent recurrence of an ulcer along the suture line. This seems to be a generally accepted observation. Finsterer[28] favors resection for gastric ulcer and found microscopic evidence of carcinoma in 23.1 per cent of the specimens removed. Ninety-five and eight-tenths per cent of his gastric ulcers were cured by resection. Walters[117] reports that a Billroth I or Polya type of resection, provided a mortality as low as 3 to 4 per cent can be shown, is indicated for large gastric ulcers, but that there is a place for destruction of the ulcer by cautery or segmental resection combined with gastroenterostomy. He reports that, following a Billroth I or Polya operation for gastric ulcer, there is a relative achlorhydria. Friedemann, out

jejunal anastomosis and restoring normal continuity by a Billroth I type of operation. Additional partial gastrectomy is indicated in some of these patients. They find, however, that only 6 per cent of the 597 cases treated required a second operation regardless of the nature or extent of the primary surgical treatment of the jejunal lesion. Many believe that it is dangerous to restore normal continuity after jejunal ulceration lest there be a prompt return of the original ulcerative lesion. Lahey and Swinton, for instance, report 40 per cent recurrent duodenal ulcers in ten patients having restoration to normal continuity after resection of the jejunal ulcer. Ginzburg and Mage, in studying eighty-six resected specimens of postoperative jejunal ulceration, conclude that while a mechanically efficient stoma tends to bring about the healing of an active duodenal ulcer, it seems to favor development of an anastomotic ulcer; and disconnection of the gastroenterostomy stoma because of anastomotic ulceration may result in reactivation of latent duodenal ulcers. For these reasons some type of resection is advocated. Bohmansson advises a Billroth I operation as a routine treatment and has a mortality of 4 per cent in such cases without acute complication. Graham and Lewis recommend a block resection of the stomach and jejunum with an end-to-end anastomosis of the jejunum and either a Billroth I or retrocolic Polya reconstruction of gastric continuity as the ideal procedure. The operative correction of a jejunal ulcer carries a rather high mortality. Finsterer in 168 operations for jejunal ulcer reports a mortality of 11.3 per cent and Ogilvie, a mortality of 19 per cent.

It would appear that when surgery is carried out for jejunal ulcer an extensive gastric resection should be considered in an effort to control adequately the acid factor.

GASTROJEJUNOCOLIC FISTULA

Gastrojejunocolic fistula is a serious complication of jejunal ulcer. In an effort to avoid this complication, if possible, Lahey and Swinton urge that, if a gastroenterostomy is to be carried out, it should be done at a point in the transverse mesocolon away from the transverse colon.

Rife reports fourteen cases of gastrojejunocolic fistula appearing in a period of six months to eleven years after gastroenterostomy for ulcer. For thirteen cases arising from ulcer there was a mortality of 20 per cent. Lahey and Swinton say that symptoms may occur from a few weeks to twenty-one years, but about 50 per cent of the gastrojejunocolic fistulas occur within two years of the original operation. They report a mortality of 63 per cent in nine cases, eight of which were operated upon. At the Massachusetts General Hospital, Allen[1] reports the incidence of postoperative gastrojejunocolic fistula as approximately 14 per cent, the mortality in ten cases being 30 per cent.

Graham and Lewis consider that the ideal operation for gastrojejunocolic fistula is block resection of the stomach, jejunum, and colon with

the opinion that it is nearer 24 per cent. Hinton and Church find 16.4 per cent and Newburger 9.7 per cent. Von Haberer regards the appearance of jejunal ulcer as so frequent after posterior gastroenterostomy the opinion that it is nearer 24 per cent; Hinton and Church find 16.4 that he thinks this operation should be considered a palliative procedure only.

Jejunal ulceration follows the exclusion operations probably next in frequency to gastroenterostomy. Allen[2] carried out this procedure in fifteen cases and gave it up because of unsatisfactory results. A high incidence of jejunal ulceration is likely to occur with a long loop anterior gastroenterostomy, and when an enteroenterostomy has been performed in association with a gastrojejunostomy.

Jejunal ulceration is not uncommon after inadequate resection and gastrojejunal anastomosis. The incidence of jejunal ulceration following resection is reported as 0.4 to 10 per cent.[65] Lahey and Marshall report recurrent ulceration after subtotal gastrectomy in 7 per cent of their cases; Cutler, in 3 per cent; Lake, in less than 2 per cent. Lahey and Swinton report in their series that 90 per cent of the original ulcers were duodenal and only 10 per cent gastric. Wright reports that jejunal ulceration did not develop in any of 436 cases following resection for gastric carcinoma. Although of rare occurrence, jejunal ulceration has been recorded following gastric resection for carcinoma.[95]

Judd and Hoerner report that 50 per cent of jejunal ulcerations occur within a year and 34 per cent occur within six months of the time of the primary operation. Grossman reports the occurrence of jejunal ulcers from twelve to eighteen years after the original operation, with seven of the twenty-three cases appearing after a lapse of five years. The location of the ulcer is recorded by Balfour[5] as marginal in 75 per cent of his cases and on the jejunum itself in 25 per cent. Lahey and Swinton report similar figures.

The treatment of jejunal ulcer is both medical and surgical. Many cases with marginal ulceration following short-circuiting operations, although obstinate, can be entirely cured by adequate medical treatment. However, medical treatment may fail to relieve the patient; there may be a free perforation, or the very unfortunate complication of a gastrojejunocolic fistula may occur. Makkas, in reviewing 131 cases of jejunal ulcer which penetrated into the peritoneal cavity, finds that jejunal ulcers perforate less often than gastrojejunal; that simple perforation usually results in a re-formation of the ulcer with a mortality of approximately 23 per cent; and that there was a mortality of 8.3 per cent in 24 cases treated radically. Judd and Hoerner in 597 cases of jejunal ulcer find a tendency toward perforation in 43 per cent.

There is some variety of opinion in regard to the surgical treatment of the jejunal ulcer which does not respond to medical treatment. Judd and Hoerner believe that the logical operation is taking down the gastro-

It is all too frequently assumed by physician, surgeon, and patient as well that surgical treatment of the ulcer insures against subsequent difficulty. But, if the best results are to be obtained, a careful medical regimen must be continued for an indefinite period.

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triple anastomoses together with a cecostomy. Scrimger reports a method of dividing the stomach above the opening in the jejunum. A cuff of stomach is cut one and one-half inches from the edge of the stoma, and its mucosa is dissected off the muscularis down to the edge of the ulcer until the stomach mucosa is removed. The stoma is then closed by suturing together the inner surfaces of the stomach cuff. The operation is completed by a gastroenterostomy. But within two years the patient had a recurrence of jejunal ulcer. Another suggestion[65] is that the stomach be divided above the fistula and that the remaining portions be anastomosed with the jejunum. After a period of three to four weeks, when the patient has recovered, the remainder of the stomach is resected along with the fistula and the right colon. Allen[1] reports a technique of aseptic repair of a gastrojejunocolic fistula. A pair of long, thin Kocher clamps is applied about the stomach side of the stoma, and this wedge-shaped section of gastric wall is freed with a cautery. The stomach is closed following the Kerr aseptic technique. Clamps are then applied to permit removal of a wedge-shaped part of the hypertrophied involved jejunum. It also is closed using the aseptic technique. The involved portion of the transverse colon is resected as well with end-to-end anastomosis, following here again the Kerr aseptic technique.

Of course the subsequent problem in the management of the gastrojejunocolic fistula is the maintenance of strict medical supervision to avoid reactivation of a jejunal or duodenal ulcer, depending upon whether or not normal continuity was established or some type of short-circuiting procedure was carried out.

POSTOPERATIVE CARE

The immediate postoperative care of these patients concerns the avoidance of shock and pulmonary complications. The usual precautions of frequent change of position and hyperventilation are followed. Marshall advocates the use of oxygen tents after prolonged gastric operations. Aspiration through a bronchoscope may relieve postoperative atelectasis. The fluid balance is maintained by the intravenous or subcutaneous administration of 5 per cent dextrose in amounts up to 3,000 c.c. a day. Water in sips is allowed after twenty-four hours. Constant gastric suction is started through the Levine tube which many prefer to leave in place during the operation. If edema develops, sodium chloride and serum protein determinations should be made, distilled water substituted for saline solution, and a low protein level raised by transfusion. The diet is very slowly increased following the classification of foods permitted under the early Sippy regimen. No solid food is given until the fourteenth or fifteenth day.[121] Should there be a tendency to vomit, constant gastric suction is resumed and maintained for as long as is necessary.

It is all too frequently assumed by physician, surgeon, and patient as well that surgical treatment of the ulcer insures against subsequent difficulty. But, if the best results are to be obtained, a careful medical regimen must be continued for an indefinite period.

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Review of Recent Meetings

REVIEW OF THE SOUTHERN SURGICAL ASSOCIATION MEETING, DEC. 5, 6, 7, 1939, AUGUSTA, GA.

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THE annual meeting of the Southern Surgical Association was held Dec. 5, 6, 7, at the Forest Hills Hotel in Augusta, Ga. Of a total of forty listed papers, thirty-six were presented.

1. **C. C. Coleman,** Richmond, Va., discussed the results of faciohypoglossal anastomosis in the treatment of facial paralysis. Whereas most cranial nerve operations are destructive, facial nerve operations are reparative and are intended to effect restoration of nerve and muscle function. Neither direct anastomosis nor nerve graft is likely to result in the desired restoration of function because of the extension of wrong fibers along the distal axis cylinders. Anastomosis with another nerve is better, preferably the hypoglossal. The loquacious person is the most undesirable type of individual for operation, because emotional expressions associated with rapid talking result in poor functional results. The author called attention to the fact that misdirection of axis cylinders is likely to result in mass action of facial muscles. He advises that the patient repress emotional expressions. Attempts to educate individual muscle groups following anastomosis are likely to result in worse functional results, such as undesirable grimaces. Anastomosis following angle tumor removals should be done within three weeks. Implantation of fascial strips as a supplement to the nerve operation may be necessary in order to prevent muscular atrophy. When the muscle does not respond to galvanic stimulation, then nerve operation is of no value. The atrophy of the tongue which follows hypoglossal nerve section is of no serious importance.

In the discussion of this paper, **Charles Bagley,** Baltimore, Md., was in accord with Dr. Coleman in respect to early repair when it is known that the nerve has been injured during angle tumor removals. Muscular atrophy is thereby minimized. **Joseph E. J. King,** New York, N. Y., favors reanastomosis for those cases of facial nerve injury which follow mastoid operations; individual nerve anastomosis when peripheral injury of the nerve has occurred; and hypoglossal anastomosis in cases of intracranial destruction of the facial nerve. **Frank H. Lahey,** Boston, Mass., advocated using the spinal accessory nerve if foreign nerve anastomosis is necessary. He feels that the loss of speech and swallowing is more undesirable than loss of arm function, which follows use of the spinal accessory nerve. **Vilray P. Blair,** St. Louis, Mo., stated that, in cases of old nerve injury or in those cases in which nerve injury has occurred within the parotid, the difficulty and futility of nerve operations make them impractical. He recommends fascial transplantation as a very satisfactory procedure under such circumstances.

In closing, Dr. Coleman agreed that nerve grafts avert the associated movements which occur when the tongue is used after hypoglossal nerve anastomosis. The question concerning the advantages of using the spinal accessory nerve rather than the hypoglossal nerve will always be a debatable one. Voice records showed no speech disturbances in his cases. Stylohyoid and digastric muscle injuries

Received for publication, February 5, 1939.

and slow regeneration of the buccinator muscle function are responsible for any speech disturbances which occur following faciohypoglossal anastomosis.

2. **Waltman Walters**, Rochester, Minn., in a presentation concerning **Operative and Postoperative Infections With Special Reference to Air-Borne Bacterial Contaminations**, affirmed the ideas of Bergmann. He discussed the factors which contribute to wound infection; i.e., rough handling, poor hemostasis. Dr. Walters reviewed the sources of infection: (1) Nose and throat of the operating team personnel. Elimination of carriers and wearing of a germ-proof mask will prevent hemolytic streptococcus infections. Masks transmit more bacteria when moist than when dry. Hart and Schiebel found a parallel between the organisms in the operating-room air and those in the noses and throats of the occupants of the operating room. (2) Hands of operating personnel. Mr. E. A. Devenish and Professor Miles, of England, found that punctured gloves were responsible for staphylococcus infections. (3) From the patient's skin. No thoroughly reliable skin antiseptic exists but the tincture of merthiolate is the best antiseptic at present available, based upon Petri dish culture studies on different antiseptics.

Precautions should be taken to purify the air of the operating room. The room and furniture should be properly cleaned and the door kept closed. Velocity of outside wind is important and precautionary measures should be taken to prevent the entrance of dust into the operating room, which increases the agar plate count. The count rises when the operating room is occupied by the surgical team and observers, so a canopy over the instrument table is desirable. According to Devenish and Miles, contamination of wounds by air-borne organisms is slight. A high *Staphylococcus aureus* infestation does not necessarily imply a high incidence of infection. Wound infection varies with geographical location. The protection which a coating of serum affords bacteria, and the undesirable effect of grease on the glass of the ultraviolet lamp were discussed. Efforts should be made first to eliminate other sources of infection before turning to air sterilization.

3. **Daniel C. Elkin**, Atlanta, Ga., discussed **Wound Infection: A Comparison of Silk and Catgut Sutures.** Wound-healing results are an index of a surgeon's ability and his surgical philosophy. Dr. Elkin classified wounds into the following groups: (1) clean, (2) potentially infected (hematoma with positive culture), and (3) infected. Fibroplasia occurs sooner in wounds closed with silk than in those closed with catgut. The liquid which accumulates in wounds closed with catgut acts as a favorable culture medium. Statistics show a lower incidence of wound infection in cases in which silk was used; i.e., 2.1 per cent compared to 9.4 per cent when catgut was used. In 188 potentially infected wounds in which silk was used, there were 7.7 per cent infections; in 312 potentially infected wounds in which catgut was used, there were 21.4 per cent infections.

4. **Frederick A. Coller**, Ann Arbor, Mich., discussed the delayed closure of contaminated wounds. About 50 per cent of wounds contaminated with gastrointestinal contents develop serious infection. He suggests packing the subcutaneous portion of the wound with flavine gauze after introducing sutures through the peritoneum and transversalis fascia. Twenty-four to forty-eight hours later, sutures, which previously have been introduced for mass approximation of the muscles or abdominal wall, are drawn taut. In a series of 22 cases in which this method was used, minor infection occurred in 2 cases and serious infection developed in only 1 case. All others healed with no infection. Bacteriologic studies were made before and after closure of the wound in 15 cases and it was found that after twenty-four hours the cultures were the same. Dr. Coller agreed with Behanes that the irritation produced by the gauze causes an inflammatory reaction which is effective as a bacteriostatic mechanism or factor. Sulfanilamide or scrubbing the wound before closure had not been tried.

In discussing the preceding three papers, **Deryl Hart**, Durham, N. C., agreed that all precautions should be taken to avert wound infection, but he insisted that air contamination is a most important factor and one which has long been neglected. Statistics show marked reduction of infection in Duke Hospital during a period in which radiation has been used. Radiation is used usually in large, primary, clean operations. **Roy D. McClure**, Detroit, Mich., asked if anaerobic cultures had been made by Dr. Coller and he wondered if aerobic conditions established by Dr. Coller's procedure were not responsible for the good results. **Hugh A. Gamble**, Greenville, Miss., cited an Austrian surgeon who permitted no talking in the operating room but used sign language instead. In his own clinic Gamble has followed the same practice and he gave a demonstration of the signs he uses. He called attention to the fact that some years ago he advocated leaving open potentially infected wounds. Gamble believes that a medicated pack acts beneficially in three ways: (1) by causing reversal of the flow of lymph, (2) by preventing inflammatory reaction, and (3) through the antiseptic substance in the gauze. **Frank K. Boland**, Atlanta, Ga., asked if cultures of catgut had been made in Dr. Elkin's cases and inquired about the relative cost of silk and catgut. **Frederic W. Bancroft**, New York, N. Y., believes that there is still another source of wound contamination and cited the obtaining of 72 per cent positive cultures from peritoneal cavity in so-called "clean cases." **William H. Prioleau**, Charleston, S. C., reported that he has been very satisfied with the results he has obtained with very fine chromic catgut. He abandoned the use of silk because, in his experience, its use was associated with an increased number of draining wounds. He believes that a fine alloy wire is superior to silk. **W. A. Bryan**, Nashville, Tenn., discussed the greater susceptibility to infection of dead, traumatized, and ischemic tissues. He emphasized that small caliber of the suture material, the tying less tightly of sutures, and the avoidance of the strangulation of large amounts of tissue are of extreme importance in wound healing. **Charles C. Green**, Houston, Tex., reported that he had obtained better results with fine chromic catgut than he had in 100 control cases in which silk was used. **Rudolph Matas**, New Orleans, La., described the revolutionary mode of treatment of wounds which he observed being practiced by military surgeons with the Republican forces in the recent Spanish Civil War. He compared the attempts to reduce bacterial contamination to a minimum as spoken of in previous papers read at this meeting with what he saw in Spain, especially in the management of compound fractures of the femur. In many instances cleansing was done in a very superficial way. Débridement was done as carefully as the conditions at the time permitted. No irrigations were done. Packs of vaseline gauze were introduced when possible; otherwise, plain sterile gauze packs were used. All wounds were left open. To assure absolute rest, casts were applied from the waist down. No antiseptics were used and it was impossible to keep up the Carrel-Dakin technique. The comparative absence of gas and tetanus infections was amazing, and, unless the temperature rose to a high level, the wounds were not opened for two to three weeks. The number of streptococcus infections was extremely low, although saprophytic infection was high. When the odor became unbearable, the cast was removed, the wound just wiped off, and the cast reapplied. Dr. Matas cited the use by a Frenchman of a helmet into which air was introduced through a tube in order to accomplish complete avoidance of air contamination.

In closing, Dr. Elkin stated that the use of catgut met with the requirements as set up by Dr. Meleney. In closing, Dr. Coller agreed that exposure of the wound to air might be an important factor in the good results obtained by delayed closure of wounds.

5. **Hugh H. Trout**, Roanoke, Va., in discussing the role of x-radiation in the treatment of carcinoma of the breast, said that there is no substitute for the radical operation for carcinoma of the breast. Radiation is *not* so well standardized at present as is surgery, thus accounting for the confusion regarding interpretation of radiation results. His opinion is based on 600 cases of carcinoma of the breast, a consideration of the literature, and conferences with radiologists. Preoperative radiation which destroys tissue is undesirable and increases the chance of recurrence. Appropriate dosage should be estimated to meet individual requirements. Young women can receive three or four times as much radiation as can older women, so the former get better results. Radiation at short intervals is more desirable in younger women because of more rapid cell division in this type of patient. As emphasized by Coutard, it is important to study the life cycle of carcinoma in the individual patient. He cited the difficulties encountered in his clinic in carrying out prolonged preoperative radiation, and in many cases forty-eight-hour preoperative radiation was employed. Preoperative radiation is valuable in the presence of palpable axillary glands, infiltration of the skin, debilitated patients, rapidly growing tumors associated with pregnancy, apparently hopeless cases, and carcinoma implantation in tract of biopsy needle. Radium is administered at the time of operation by introducing fifteen or twenty radium needles of 3 to 5 mg. each. Postoperative radiation is started after ten days; if begun earlier, the graft will be killed. Through public education, cases are being brought in earlier and this accounts, at least in part, for improved results. Relief of pain can be accomplished by means of x-radiation in some cases. Dr. Trout also spoke of radiation of the pelvis and suggested that the good effects of radiation in carcinoma of the cervix may be due in part to the simultaneous irradiation of the ovaries.

6. **Barney Brooks**, Nashville, Tenn., in a discussion of the present status of the radical operation for carcinoma of the breast, quoted statistics and cited observations of others to the effect that local removal or simple mammectomy, combined with radiation, or the use of radiation alone, is equally good or superior to the radical Halstead operation. He gave the principles underlying the radical operation, notably the removal in mass of all tissue which might be involved, regardless of concepts concerning the mode of extension of carcinoma; i.e., whether by continuity or by embolism. Dr. Brooks cited the remarkable similarity of the original publications by Halsted and by Meyer concerning the treatment of carcinoma of the breast. The findings at the time of operation are of more prognostic value than is histologic classification. The radical operation is the procedure of choice.

In discussing the last paper, **Roy D. McClure**, Detroit, Mich., felt that many surgeons who say that they perform the Halstead operation are not, in reality, employing the technique advocated by Dr. Halstead, as this type of operation frequently necessitates large grafts. Dr. McClure referred to an apparatus devised recently which greatly facilitates obtaining large sheets of skin for grafting purposes.

Charles C. Lund, Boston, Mass., classified the inoperable cases of carcinoma of the breast into cases: with growths fixed to chest wall, with bone and chest metastasis, and with marked edema of the skin. In 40 per cent of instances enlarged lymph glands are not recognized at the time of operation. Pathologic reports confirm the findings in 90 per cent of cases of carcinoma of the breast in which glands are felt. Lund is not now employing radiation of the pelvis as an adjunct in the treatment of carcinoma of the breast. He does not at present administer preoperative radiation, but postoperative radiation is employed more extensively than formerly. **Rollin A. Daniel**, Nashville, Tenn., presented ad-

ditional data regarding patients referred to by Dr. Brooks. He discussed the average duration of life after the tumor is first noticed by the patient and the comparative results whether or not x-ray is employed. **Walter O. Bullock,** Lexington, Ky., in discussing Dr. Trout's paper, deprecated radiation of the pelvis and inadequate breast operations. **James F. Mitchell,** Washington, D. C., stated that Bloodgood carried the operation even further than Halstead. **L. Wallace Frank,** Louisville, Ky., reported that, in 192 cases of carcinoma of the breast, he had only 3 skin recurrences. In his experience, Dr. Frank stated that skin grafting following radical breast operations has not been necessary.

In closing, Dr. Trout stated that radiation is likely to cause carelessness in surgical removal. He has treated some cases which at first appeared inoperable, but which, following radiation, became operable. Better results have been obtained when there is a single large axillary mass than when there are many small shotty ones. He is presently not enthusiastic about radiation of the pelvis. Dr. Brooks, in closing, said that he believes that operative treatment is on trial for its life. Before condemning it, one must be certain that it has been carried out properly. However, the validity of the basis for the radical operation has been reasonably questioned, and reinvestigation of the problem is, he believes, in order.

7. **J. M. Donald,** Birmingham, Ala., reported 21 cases of scalenus anticus syndrome, 5 of which had an associated cervical rib. In many instances the patient did not have a long neck. In operative procedure for this condition, the thoracic duct may be lacerated. Bilateral tenotomy was performed in 3 cases with a bilateral scalenus anticus syndrome. One case had preoperative gangrene with atrophy of muscles of the arm and shoulder. A section of muscle was removed in some cases. Of 16 cases submitted to operation, 14 were relieved. Some cases were immediately relieved, and the longest time elapsed before relief was obtained was six weeks. Dr. Donald cited 19 cases in which only mild symptoms were found and which needed no operation. The scalenus anticus syndrome is more common than most surgeons realize, and is accountable for many cases of obscure brachial neuritis.

8. **K. H. Aynesworth,** Waco, Tex., suggests the term cervicobrachial syndrome to replace scalenus anticus syndrome. He reported several cases which he considered illustrative of the traumatic origin of the syndrome, some of the neuritic and others of the vascular types. Resection of the rib following tenotomy of the scalenus anticus was necessary in several instances. Dr. Aynesworth presented a number of possible mechanisms for the development of the syndrome.

In discussing the latter two papers, **Mims Gage,** of New Orleans, La., referred to conditions which might be responsible for the scalenus anticus syndrome, including a low origin of the cervical plexus, failure of descent of the shoulder girdle, and spasm of the scalenus anticus muscle. He emphasized the importance of novocain injection of the anterior scalene muscle as a diagnostic measure in the diagnosis of the condition. In many cases, the brachial plexus and subclavian artery pass through the muscle. Dr. Gage drew attention to both the scalenus anticus major and minor muscles; the latter has been demonstrated in 60 per cent of special dissections. He suggested that an effort be made to locate the scalenus minimus muscle behind the plexus. Most cases of scalenus anticus syndrome occur in women. **Lucian Landry,** New Orleans, La., reported four cases of displaced subclavian artery which had been misdiagnosed as aneurysms. They were all cases with a cervical rib. **Alton Ochsner,** New Orleans, La., presented a simple diagnostic test; i.e., putting the scalenus anticus muscle under tension, by having the patient turn his head to the same side, will induce the symptoms. Oscillometric tracings may also be of diagnostic value. Because recurrences sometimes occur after simple division, excision of a segment of the hypertrophied muscle should

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from the finger to the shoulder, which latter region did not become involved until the patient was 21 years old. The arm was amputated and ten years passed before two new angiomatous formations occurred, one in the axilla and another in the right sixth intercostal space. Because of thinning skin and threatening rupture, excision of the axillary mass became mandatory. The hemostatic problem here was most serious. Dr. Matas used turpentine as a hemostatic agent for the bleeding granulation tissue which followed operation. The mass was, in effect, a tremendous sieve of arteriovenous aneurysms. Subsequently, a mass developed, apparently involving the subclavian artery. Compression of the mass raised the blood pressure and resulted in slower pulse, and fluoroscopic examination showed diminution of the size of the heart. The subclavian artery was ligated following temporary arrest of the innominate artery, and subsequently amputation was done. A recent report from the patient indicates that he is well and active, has married, and has a child 4 years old who has no angiomas. Dr. Matas is of the opinion that anlage embryonic cell nests remaining dormant for years account for the lesion. Although at first the tumor was thought to be clinically malignant, although histologically benign, the survival of the patient proved the case to be clinically benign as well. The area on the chest was treated with x-rays and the lesion disappeared.

Barney Brooks, Nashville, Tenn., commented on the courage of Dr. Gatch in attacking the large aneurysm. In discussing Dr. Matas' paper, Dr. Brooks spoke of the danger of air embolism occurring during operations on angiomas. **Arthur W. Allen**, Boston, Mass., stated that there are not many cases of syphilitic aneurysms in New England, nor are many cases of arteriovenous aneurysms encountered in that territory. However, many cases of aneurysms due to arteriosclerosis are observed. This latter type of aneurysm frequently occurs in the popliteal region and leads to thrombosis. In one such case, injection of the lumbar sympathetic ganglia, first with novocain and subsequently with alcohol, resulted in the disappearance of the pulsating mass and, he believes, prevented the development of gangrene. **James M. Mason**, Birmingham, Ala., demonstrated a method which he has developed for the control of main arterial supply in dealing with aneurysms at the base of the neck. An incision is made parallel to the sternomastoid, then parallel to the clavicle, and finally out to the anterior axillary fold. Flaps are made and the clavicle is divided distal to the attachment of the sternocleidomastoid muscle. By retracting the divided clavicle, all important structures are exposed. **Joseph A. Danna**, New Orleans, La., discussed the inadvertent entry into an aneurysm and said that hemorrhage may be controlled by occlusion of the opening into the artery by means of a finger through the sac. He also drew attention to the importance of looking for a second or third opening. **J. L. Campbell**, Atlanta, Ga., discussed the difficulties and dangers associated with opening of the sac before placing controlling catheters or ligatures proximal to and distal to the aneurysm. He recommended the resection of part of the clavicle rather than simple division of that bone.

In closing, Dr. Gage reiterated that sudden ligation of major arterial trunks is extremely dangerous. He did not offer the method of developing collateral circulation which he described as a cure, but rather as an adjunct in the treatment of aneurysms involving the peripheral arteries.

12. **Frederic W. Bancroft**, New York, N. Y., advocated a modified Kondoleon operation for sclerosed leg with ulceration. The operation is intended for cases with varicose veins associated with so much fibrosis that injection, ligation, or both of these procedures, cannot be expected to afford, or have proved incapable of affording, relief. The performance of the modified Kondoleon operation increases the success of skin grafts applied after excision of varicose ulcers. Fol-

be done. The majority of his cases were on the right side, although most of Dr. Donald's were on the left. The syndrome is particularly likely to be induced or aggravated while the patient is sweeping with a house broom.

Dr. Donald, in closing, reported only one case in his series which was definitely associated with trauma. Two cases of scalenus anticus syndrome followed anesthesia; one was an obstetrical patient, who was given rectal anesthesia; and one was a patient who had been operated upon under spinal anesthesia for appendicitis. Eighteen cases had more severe pain at night. Pain is relieved by throwing the shoulders back. Sleeping reverses this and causes pain. In conclusion, Dr. Aynesworth states that in the instance of tractor drivers suffering with the syndrome, he was able to afford relief by means of a figure-of-8 bandage or brace for the shoulders.

9. **Mims Gage**, New Orleans, La., discussed the method of developing the collateral circulation of arterial aneurysms of the peripheral arteries. Collaterals usually developed spontaneously. Sympathetic nerve irritation is likely to occur, and tends to cause spasm of the artery and the collaterals distal to the aneurysm with resultant diminished blood volume flow and nutritional deficiencies. The treatment of choice for arterial aneurysm is the obliteration of the vessel. The methods for testing the circulation are: (1) Matas compressor, (2) oscillometer, (3) plethysmograph, (4) Moszkowicz method, and (5) thermocouple. Arteriograms have shown that there is a deficiency of collateral circulation in the region of the knee and, in some instances, in the region of the elbow. Ischemic gangrene developing after the ligation of large arteries, as reported by Dr. Matas, occurs in 5.2 per cent of cases, and, according to Tuffier, in 40 per cent of cases. Dr. Gage cited a mortality incidence in ligation of the common carotid artery reported by DeFourmestraux as follows: for hemorrhage, 54 per cent; for tumors, 46 per cent; for aneurysms, 13.5 per cent; and for pulsating exophthalmus, 7 per cent. The various methods for developing collateral circulation include the Matas compressor, alternating positive and negative environmental pressure, and intermittent venous occlusion. The rationale of sympathetic nerve section is to overcome vasospasm, produce vasodilatation, increase blood volume flow, increase arterial blood volume flow distal to ligation, increase the size of the vasa vasorum, and prevent ischemic gangrene. The types of sympathetic nerve section are classified as: chemical, including novocain and alcohol; and mechanical, including surgical. The aneurysmal sac becomes smaller and the associated arterial spasm is relieved. A series of cases was reported in which the results had been most gratifying.

10. **W. D. Gatch**, Indianapolis, Ind., reported a case of large false aneurysm of the right subclavian artery caused by a gunshot wound. A pulsating mass developed and the axillary artery was ligated. Years later, after coughing, the mass in the supraclavicular region suddenly increased to the size of a grapefruit. Preliminary ligation of the innominate gave incomplete hemostasis. An endaneurysmorrhaphy was done with preparations made for a possible massive hemorrhage. Part of the manubrium and right clavicle were resected. The sac was opened and the opening communicating the aneurysmal sac and the artery was instantly occluded by means of a finger. The opening could not be sutured nor could the artery be ligated through the sac, so the opening was plugged with a flap of the sac wall. Eight months postoperatively, examination revealed an excellent result, there being no pulsation or mass. Dr. Gatch suggested that a free graft of sac wall might be used instead of a flap, and he added that this should not be done before the false sac has developed; i.e., after three or more months.

11. **Rudolph Matas**, New Orleans, La., gave a synopsis of a case of cavernous hemangioma which was evident at birth in 1904. The lesion gradually progressed

14. **Addison G. Brenizer,** Charlotte, N. C., in a presentation concerning hemolytic jaundice, stated that hemolysins created in the spleen were responsible for the destruction of the red blood cells and that blood given by transfusion is also hemolyzed in the same way.

15. **Charles Gordon Heyd,** New York, N. Y., considered the factors of mortality in operations on the external biliary system and a collective series of 3,986 operations performed on the biliary tract over a period of seventeen and one-half years, with a 7 per cent mortality. The operations for chronic cholecystitis were performed by 53 surgeons; whereas, 31 surgeons performed the operations upon the acute cases. One-fifth of the cases were Dr. Heyd's personal ones. Malignancy, embolism, coronary thrombosis, inadequacy of preoperative treatment, and lack of judgment in selecting the proper operations, as well as delay on the part of the patient, were presented as factors which maintain the high mortality rate in operations on the biliary tract. The preparation of patients with cholecystitis for from six to twenty-four hours before operation has been statistically shown to halve the mortality associated with immediate operation. Longer periods of preparation, however, are associated with a rising mortality. Previous attacks of acute cholecystitis double the mortality.

16. **W. H. Parsons,** Vicksburg, Miss., reviewed statistics on the immediate and end results of cholecystectomy in American and foreign clinics. The mortality in previously reported series varied from 1 to 12 per cent. The mortality in Parsons' 100 personal cases of gall-bladder and bile duct operations was 6 per cent. Better late results were obtained in those cases in which stones were present. Dr. Parsons felt that allergic patients should be cautiously subjected to operation.

17. **Arthur W. Allen,** Boston, Mass., reported on follow-up observations after operations for stone in the common bile duct, with special reference to graded dilatation of the sphincter of Oddi. He referred to a report presented before this society five years ago regarding the passage of bougies in operations involving the bile ducts, and stated that the common bile duct should not be opened and then closed without leaving a T-tube in place, especially if the papilla has been instrumented. He believes that retrograde dilatation of the sphincter of Oddi is inferior to dilatation beginning within the duct. He uses Bakes' graduated dilators or sounds, and emphasized that the dilators are not "common duct" dilators. The smallest dilator is 3 mm. and the largest one is 14 mm. in diameter, and it is rarely necessary to use a dilator larger than the 10 mm. size. The larger ones may be used to advantage in cutting down on the sphincter of Oddi. The average dilatation has been 7 mm., which corresponds to that effected by the No. 20 French catheter, devised by Cheever for the same purpose. The mortality was less in the common duct cases in which dilatation was done; i.e., 3.9 per cent in the dilated cases than in the nondilated cases (5.1 per cent). However, the mortality in the dilated cases was higher than that in the entire group of biliary tract operations. In secondary operations when dilatation was done, there was a 1.42 per cent mortality; whereas, when dilatation was not done, there was a 5.14 per cent mortality. Fatal bile peritonitis and pulmonary complications were greater in the dilated cases, but, by correcting the condition responsible for bile peritonitis, the increased mortality due to this complication can be prevented. The patient must be taken back to the operating room and exploration done if no bile is draining from the tube in the common bile duct or if bile is seen on the dressings, although not coming through the tube.

In discussing the last three papers, **Frank H. Lahey,** Boston, Mass., observed that mortality and morbidity in cases with stone in the common bile duct are

lowing the operation, induration and coldness of the leg disappeared and the calf of the leg became soft. Dr. Bancroft advises performance of the operation only in severe cases, and referred to Dr. Hugh Trout's report on the same procedure in 1929. Dr. Bancroft believes that the encircling scar tissue is the most important factor, a concept different from that of Dr. Trout. It was recommended that the placing of grafts be done seven to ten days following Kondoleon operation, as immediate grafting was not successful. Compression or support by a Unna paste boot should be continued for some time following the operation. The average duration of ulcers was fourteen years. Of 20 cases reported, 12 have remained healed, 2 had fair results, and 2 were failures. Too great a delay in skin grafting will result in failure of the entire procedure. The incision must be made long enough and must be continued until soft tissue is encountered, at both ends of the incision.

13. **Carrington Williams**, Richmond, Va., in reporting cases of hysterical edema of the hand and forearm, cited various hysterical conditions which produce lesions appearing to be surgical. Edema may be caused by venous congestion with resulting increased tissue pressure, and the size of the leg is increased following prolonged standing. Dr. Williams reported three cases in which hysteria was a cause of edema. The first case was that of a girl, 14 years of age, who complained of painless pitting edema of the left hand and forearm. The arm was red and hot and its appearance suggested the existence of inflammation. Twelve hours of recumbency in bed resulted in relief. This case was considered to be one of major hysteria caused by unhappiness of the child. The second case, under the care of Dr. William F. Rienhoff, Jr., was that of a man, 40 years of age, who complained of red, tender swelling of the arm and forearm. He had been treated by a Hopi Indian medicine man. The arm and forearm were elevated in a plaster of Paris cast with resulting great improvement, except that the mobility of the fingers was not restored. The third case was that of an elderly Chinese beggar who had areas of ulceration of the hand. The results were not so good in this case. Dr. Williams called attention to the fact that the left hand was involved in all three cases. He proved experimentally that maintenance of a normal upper extremity in the dependent position for four and one-half hours will cause an increase in the volume of the part.

In discussing this paper, **Addison G. Brenizer**, Charlotte, N. C., stated that he believes that the edema associated with varicose veins is due to a lymphangitis and not to a phlebitis. In discussing Dr. Bancroft's paper, **Hugh H. Trout**, Roanoake, Va., said that, no matter how extensive the Kondoleon operation, there will be recurrences. **Margaret Stanley-Brown**, New York, N. Y., in discussing Dr. Bancroft's paper, stated that, if the Kondoleon operation is to be successful, the patient should remain under observation for six weeks. Dr. Stanley-Brown presented some of the pitfalls in the performance of the Kondoleon operation and advocated avoidance of operation in the presence of infection, preoperative elevation of foot with bed rest, and postoperative application of a Unna paste boot. A single incision was said to result in sufficient gaping; 1:5,000 acriflavine dressings are used in preparation for grafting. Hospitalization for two weeks before and for four to six weeks following the operation is usually required. **Howard Mahorner**, New Orleans, La., discussed Dr. Bancroft's paper and called attention to the fact that back pressure, infection, and scarring are factors responsible for persistence of varicose ulcers. He mentioned the importance of low ligation or the excision of segments of veins where leaks occur. He also discussed the comparative tourniquet test. **Robert L. Rhodes**, Augusta, Ga., spoke of the importance of removing foci of infection in order to avert recurrence following the Kondoleon operation.

cases on the above basis; therefore, he decided to employ a test which would be more dependable in the diagnosis of acute pancreatitis. He selected Somogi's starch test for amylase. The mean level of amylase in this method lies between 70 and 200. Some of his cases had readings as high as 1,600, and in one case a reading of 3,600 was obtained. Acute pancreatic abscesses should be drained, but at present not many surgeons operate for the acute fulminating hemorrhagic type. These cases often require exploration for other possible lesions, such as ruptured peptic ulcers, acute cholecystitis, etc. Splitting the capsule of the pancreas is not effective and should not be done. Drainage should be established in order to allow the sequestration of necrotic masses of pancreatic tissue. The characteristic opalescent material may be obtained by diagnostic aspiration of the peritoneal cavity. The average mortality when early operation is done is 49 per cent; whereas, delayed operation performed in 161 foreign cases was associated with a mortality of only 18 per cent in all varieties of the disease. The amylase test is of practical value in the edematous type, which, incidentally, tends to subside. Acute pancreatitis and acute parotitis are analogous in that in both of the conditions the blood amylase is elevated. Because of the favorable results obtained in the treatment of parotitis by x-radiation, Dr. Morton has employed x-ray therapy in cases of acute pancreatitis. Through two portals, 250 to 450 r. units were administered with encouraging results.

In discussing this paper, **Roy D. McClure**, Detroit, Mich., discussed the Turner and Cullen signs. By means of a colored lantern slide, he demonstrated the discoloration in the flanks, more marked on the left side, which was observed in one of his cases of acute pancreatitis. **Irvin Abell**, Louisville, Ky., questioned the occurrence of pancreatic edema as a distinct and final entity. The various degrees of pancreatitis are merely different stages in the same process. The less done to the pancreas, the better, and drainage of the gall bladder is a helpful procedure in some cases. **George G. Finney**, Baltimore, Md., reported on 21 cases of acute pancreatitis admitted to the Union Memorial Hospital. In only a few instances was the accurate diagnosis made. Immediate operation was performed in all cases, and in some cases the gall bladder was drained. The region of the pancreas was drained, but the pancreas was not incised.

19. **William E. Lower**, Cleveland, Ohio, showed two motion pictures, one showing the Coffey method of ureteral transplantation, and the other one illustrating the technique of cystectomy.

In discussing these pictures, **Addison G. Brenizer**, Charlotte, N. C., described the operation of bilateral ureteral transplantation which he has previously presented. **Henry L. Douglass**, Nashville, Tenn., stated that he had tried Brenizer's operation, with resulting stenosis of the ureter. In using the operation demonstrated by Lower, he warned against taking deep bites into the ureter along the portion buried in the gut wall. In experiments on dogs he found that poor healing often led to the ureter entering directly into the bowel. To avert this undesirable occurrence, he advocates placing a drain along the bed in which the ureter is buried. **W. Lowndes Peple**, Richmond, Va., reported three cases of ureteral transplantation. **Francis Randall Hagner**, Washington, D. C., believes that in transplanting dilated ureters it is better to introduce a catheter through the ureter.

20. **Ambrose H. Storck**, New Orleans, La., presented a series of 46 penetrating wounds of the abdomen, 35 of which were gunshot wounds and 11 of which were stab wounds. The cases were statistically summarized and analyzed in relation to the recent advances in surgical practice which are applicable in the treatment of these injuries. The importance of hemorrhage in relation to the management and prognosis, the preoperative preparation, the criteria for the selection of cases

related to the time factor. Since the infection factor is so important and prolongation of the disease means prolongation of the infection, the relation of infection to common duct stone should be appreciated by the medical men. Dr. Lahey advocates more frequent common duct exploration because stones are often present in the ducts and not in the gall-bladder. Dr. Lahey stressed the importance of an adequate incision in the abdominal wall, but said that elevation of the back of the patient is of no value. The surgeon should pack off the stomach, intestines, and omentum to the left until the foramen of Winslow and the vena cava can be seen. Then the foramen of Winslow should be blocked off to prevent spillage into the lesser peritoneal sac. Dr. Lahey believes that exploration of the duct is especially important in operations for acute cholecystitis. If the bile is anything but normal in color, the duct should be drained. **W. D. Gatch**, Indianapolis, Ind., advocated the use of a silk urethral bougie instead of the metal dilators. He believes that cholecystitis is primarily chemical and that infection is secondary. In discussing Dr. Heyd's paper, **W. A. Bryan**, Nashville, Tenn., spoke about the harm of long delay in instituting operative treatment and advised against performing other operations at the time of operations on the biliary tract. **Harold L. Foss**, Danville, Pa., reported eight cases of gallstone ileus, including a fatal case in which there were two stones, the second one having been overlooked. A search should be made for multiple stones in cases of gallstone ileus. **Henry Cave**, New York, N. Y., classified the terms commonly used in reference to operations for acute cholecystitis, as follows: immediate or emergency, within three hours; early, twelve to seventy-two hours; delayed, three days or longer. He advocated a period for the study and preparation of the patient before performing any operation for acute cholecystitis. Dilatation of the papilla results in a shorter period of bile drainage following operations on the common duct. **Waltman Walters**, Rochester, Minn., advocated being content with operations on the gall bladder or the bile ducts, deprecating even the simultaneous performance of an appendectomy or pyloroplasty. He commended dilatation of the sphincter of Oddi in selected cases; i.e., those in which the common bile duct is enlarged. He said that there are still indications for the performance of cholecystostomy and recommended this operation for poor risk cases, and in diseases of the head of the pancreas. **R. L. Sanders**, Memphis, Tenn., cited two periods in his experience in the surgical treatment of biliary tract diseases. He has improved his results by better preoperative preparation of his patients. He described a method of conserving bile by elevating the tube extending to the common duct above the level of the bed. **Hubert A. Royster**, Raleigh, N. C., expressed the feeling that a new chapter is about to be written in the history of biliary surgery. In earlier periods, only the gall-bladder stones were removed; then the stones and the gall bladder were removed. The final satisfactory solution of the problem will come when it is possible to control the primary cause of biliary tract diseases, which is a disease or abnormal function of the liver.

18. **John J. Morton**, Rochester, N. Y., reviewed the diagnosis and treatment of acute pancreatitis and stated that the diagnosis of this condition is very unsatisfactory. At least three types of inflammation should be considered: edematous, hemorrhagic, and suppurative. Sudden and severe pain is evidenced in all cases. Although vomiting is present in 75 per cent of the cases, it is not a reliable factor. Jaundice is present in only 33⅓ per cent and shock is present in some cases. There is a relative increase in pulse as compared to temperature. Tenderness is usually present in the left costovertebral area. Spasm and distention are sometimes present. The white blood cell count averages 17,000 cells per cubic millimeter. There is sometimes an accompanying glycosuria. Most of the patients are obese. Correct diagnosis is made in only 17 per cent of the

23. **Edwin P. Lehman,** Charlottesville, Va., presented a preliminary report on the experimental control of intra-abdominal adhesions. Heparin was tested for its effect in preventing the deposition of fibrin following the division of peritoneal adhesions. Both dogs and rabbits were used in the experiments. Peritonitis was produced by perforating the appendix. Three thousand units of heparin were introduced into the peritoneal cavity at the time of operation and repeated on the first and second postoperative days. Control observations were made using (1) saline solution, (2) amniotic fluid, and (3) nothing. The group of animals to which heparin was not administered developed 150 per cent as many adhesions following the division of previously existing adhesions; whereas, there was only a 26 per cent recurrence of adhesions in the instance of the animals who received heparin. Although already formed thrombi are not affected by heparin, the possible danger of hemorrhage following the use of heparin has so far made Dr. Lehman hesitant to recommend the method for clinical use. **R. L. Sanders,** of Memphis, Tenn., said that he has used amniotic fluid in about 300 cases during the past ten years, with gratifying results. **Mims Gage,** New Orleans, La., spoke of the use of papain solution for the prevention of the recurrence of peritoneal adhesions. **Thomas C. Davison,** Atlanta, Ga., reported follow-up observations on cases in which mineral oil was introduced into the peritoneal cavity for the intended purpose of preventing adhesions. He reoperated on some of the cases and found oleomas, which were at first diagnosed as sarcomas, both clinically and by pathologists. He now uses amniotic fluid. **Joseph E. J. King,** New York, N. Y., said that he has used papain solution in 30 cases with peritoneal adhesions, and he added that he plans to use it for the prevention of meningeal adhesions.

25. **H. A. Gamble,** Greenville, Miss., discussed anchorage of the mobile cecum, and based his conclusions concerning this procedure on 310 cases, most of whom were females. The normal fixation of the cecum is related to normal function of the entire gastrointestinal tract. He cited four grades of abnormal mobility of the cecum and reviewed the theories which have been offered to explain the development of mobile cecum. On the basis of the clinical manifestations produced, he classified the types into the gastric, biliary, renal, duodenal, and right iliac fossa types, and added that sometimes the symptoms are systemic as a result of abnormal intestinal absorption due to intestinal stasis. Simply removing the appendix does not afford relief to patients with a mobile cecum. Fixation of the cecum on the psoas shelf has been suggested, but Dr. Gamble recommends forming a new bed for the cecum and the ascending colon along the right peritoneal gutter. From 210 replies to questionnaires, he found that 75 per cent were cured, 15 per cent were improved, and 10 per cent were unimproved. There were no mortalities.

In discussing this paper, **Charles Rosser,** of Dallas, Texas, said that he believed that the after care which the patients received must have contributed to Dr. Gamble's good results. Dr. Rosser does not believe that the operative procedure is necessary, and he has abandoned it.

26. **M. J. Henry,** Louisville, Ky., in a presentation devoted to acute intestinal obstruction, outlined the differences between obstruction due to neoplasia and ileus due to other causes. He reviewed 182 cases of nonmalignant obstruction, 70 per cent of which were operated upon by **Irvin Abell,** Louisville, Ky., and 30 per cent of which were operated upon by himself. Pain and vomiting were present in 95 per cent of the cases. Distention was the next most frequent sign. Dr. Henry reported 20 deaths in the group of cases in which obstruction was due to adhesions. In 9 of these cases, intestinal resection had been performed. The mortality was higher when the patients had not had a previous operation, because of the delay in diagnosis in such cases. He reported a 19 per cent mortality in

for operation, the methods for determining the optimal time for operation, and the postoperative care of patients with penetrating wounds of the abdomen were considered.

In discussing this paper, **Rudolph Matas**, New Orleans, La., said that Charity Hospital in New Orleans has had more material available for studies on this subject than any other hospital in the world. Memphis, Tenn., Atlanta, Ga., Louisville, Ky., and Birmingham, Ala., share New Orleans' unenviable position in respect to the high incidence of gunshot and stab wounds. It is important to study the wounds in detail, and important statistical compilations are being made from the recent Spanish Civil War experiences. Dr. Matas expects that China and Japan will furnish much important data on the subject of penetrating wounds of the abdomen. **Rettig A. Griswold**, Louisville, Ky., expressed the opinion that in icepick wounds laparotomy is not necessary, since such small perforations as might occur will spontaneously become effectively sealed off. The peritoneoscope has been used for the detection of blood, intestinal contents, or perforations, thus avoiding about 10 per cent of the unnecessary operations.

21. **Roger Doughty**, Columbia, S. C., in a report on chronic obstruction of the first portion of the duodenum by congenital bands, described observations which he and **George H. Bunch**, Columbia, S. C., have made. He discussed the symptoms which simulate those produced by pyloric stenosis. The operative procedure employed in their cases, i.e., cutting along the outer right avascular peritoneum, was illustrated. The bands do not seem to reform and recurrence of symptoms does not occur. The belief was expressed that the condition has frequently been overlooked and thereby many lives have been lost.

In discussing this paper, **Lon W. Grove**, Atlanta, Ga., reported two cases of congenital intestinal abnormalities. One was a case of malrotation and the other a case of duodenal obstruction. **Kenneth Aynesworth**, Waco, Tex., discussed the anthropologic aspects of malrotations of the intestinal tract.

22. **Roy D. McClure**, Detroit, Mich., in a consideration of operative technique in partial gastrectomy, emphasized that the ease with which this operation can be done is related to the condition of the patient. He stated that he leaves an indwelling gastric catheter in place for five days. Under spinal anesthesia, an incision is made along the midline, with the removal of the umbilicus in many cases. He places a specially designed clamp around the pylorus after its mobilization, and he uses a modified Furniss clamp across the duodenum. Two hundred cubic centimeters of an antiseptic, developed by Hartmann, is placed in the stomach two hours preceding operation. In order to avoid slippage of the stomach through the Payr clamps, which he applies to the stomach, Dr. McClure uses Payr clamps to the tips of which clamps are attached. He performs the Hofmeister-Finsterer type of anastamosis.

In discussing the paper, **Samuel Marshall**, Boston, Mass., said that he operated on only 8.2 per cent of duodenal ulcers, but on about 33 per cent of gastric ulcers. He stated that surgeons at the Lahey Clinic now do seven resections to three of the more conservative operations. He reported only 1 death in the last 88 resections, this fatality being due to pulmonary embolism. He said that Dr. McClure has had 1 death in 53 resections. He depends upon the high gastric acidity or the preoperative administration of hydrochloric acid for sterilization of the stomach. It is his practice to do an antecolic anastomosis, because an anterior anastomosis is easier to perform and, furthermore, it is easier to take down such an anastomosis should a marginal ulcer develop. An enteroenterostomy is not done because of the undesirable deprivation of the anastomosis site of the alkaline secretions which follows this procedure.

life is possible after removal of the spleen. **John deJ. Pemberton,** Rochester, Minn., cited that since 1904 in 800 cases of splenectomy at the Mayo Clinic there have been only 4 cases of solitary cyst, so he agrees with Dr. Roberson that they are rare. Three of these cases were females. There was no history of trauma in any of the cases treated at the Mayo Clinic.

29. **Warfield M. Firor,** Baltimore, Md., in discussing the treatment of Addison's disease by the implantation of synthetic hormone, stated that destruction of the adrenal cortex, as described by Addison, has been known for only eighty-five years to be the cause of morbidity and death. In 1930, Pfiffner and Swingle isolated a potent adrenal cortex extract. In 1933, Loeb, of Columbia University, drew attention to the value of administering large amounts of sodium chloride in the treatment of Addison's disease. Dr. Firor reiterated that potassium is also important. His report was concerned with observations made following the implantation under the skin of pellets of desoxycorticosterone acetate. One pellet of the substance, weighing 100 to 150 mg., must be implanted for each 0.5 mg. daily requirement of the hormone. Because patients with Addison's disease are such poor risks, the pellets are inserted in the operating room, in order to reduce to a minimum the possibility of infection at the sites of implantation. Sometimes as many as sixteen pellets may be introduced, thereby furnishing a supply of hormone sufficient for as long a period as nine months. Following this therapy, the plasma volume increases, the blood pressure is remarkably elevated, and there is an increase in body weight. Of the 17 patients treated with pellets, 15 have resumed their usual duties. Regeneration of cortical tissues, due to general improvement of the patient following desoxycorticosterone acetate, makes smaller subsequent doses of the hormone sufficient. It was anticipated that sufficient regeneration may eventually occur in some cases so that adequate normal function will continue without hormone therapy.

In discussing this paper, **Harvey B. Stone,** Baltimore, Md., said that Dr. Firor's work illustrated what might be accomplished by the cooperation of chemists, physiologists, and surgeons. Dr. Stone drew attention to his own work on the transplantation of tissues which secrete hormones. He transplanted adrenal cortex in three patients, all of whom were at least temporarily improved but all of whom are now dead. **George J. Heuer,** New York, N. Y., asked if there is any danger in the use of pellets.

Dr. Firor, in conclusion, stated that pellets should be hard in consistency in order to avert undesirably rapid absorption of the hormone. He always keeps his patients under observation for several weeks in order to determine the rate of absorption.

30. **John deJ. Pemberton,** Rochester, Minn., in discussing thyroglossal duct fistula, referred to Sistrunk's advocation of the complete operation for this developmental anomaly. Others before him had described or advised complete operations, but Sistrunk developed a method which assures removal of the entire tract, even when it is impossible to trace the duct throughout its entire length. The embryologic factors leading to the formation of thyroglossal sinus or fistula were presented. Pemberton reported 293 cases, some of the patients being past 60 years of age. Of 261 cases followed successfully, there were 4 cases (1.5 per cent) of recurrence. Many operations had been done previously on these patients, as many as ten operations in one case. The complete operation should be postponed until acute infection has been controlled. Preliminary incision and drainage is sometimes necessary. A transverse incision is made at the level of the hyoid. Since the portion of the tract above the hyoid cannot be seen, that portion of the tract must be cored out. A finger placed in the mouth against the base of

53 cases of external hernia and a 50 per cent mortality in 10 cases of volvulus. In 6 operative cases of gallstone ileus, there was a 50 per cent mortality. Of 12 cases of intussusception, 11 were operated upon, with a 36 per cent mortality. One of the fatal cases had a mesenteric thrombosis. The single patient in this series in whom intestinal obstruction was due to imperforated anus lived. The total mortalities, according to some of the surgical procedures employed, were as follows: enterostomy, 100 per cent; freeing adhesions and enterostomy, 39 per cent; freeing adhesions alone, 17 per cent. In the future, operative procedures will have much less place in the therapy of intestinal obstruction, because of the development of apparatus and criteria for the nonoperative management of ileus.

In discussing this paper, **Elmer H. Adkins**, Miami, Fla., reiterated the importance of early diagnosis in intestinal obstruction. **James D. Rives**, New Orleans, La., discussed the pros and cons of treatment of obstruction with the Miller-Abbott tube and warned against the improper use of this method. He reported 17 cases of ileus in which the Miller-Abbott tube was used at Touro Infirmary. In 14 instances the tip of the tube passed through the pylorus. Two of the failures occurred in children. Dr. Rives reported 4 deaths in the series, none of which were attributable to the use of the tube. In one case death caused by pneumonia averted death due to intestinal necrosis, which autopsy revealed was impending as a result of overinflation of the balloon. He said that now he never introduces more than 40 c.c. of air into the balloon. Subsequent operation was necessary in one of the cases. If free bowel movement (diarrhea) does not occur within twelve hours, the tube treatment should be considered unsuccessful. **Edward Vernon Mastin**, St. Louis, Mo., reported the case of a child 5 years of age who within a period of 14 months had three ileocolic intussusceptions, for which the following operations were performed: (1) reduction of the intussusception, appendectomy, and suture of the ileum to the cecum; (2) simple reduction of the intussusception; and (3) fixation of the cecum.

27. **Charles H. Watt**, Thomasville, Ga., in presenting a modified spur-crushing clamp, spoke about exteriorization operations employed in the treatment of lesions of the left colon. The clamp which he has devised eliminates long convalescence, undesirable persistence of the colostomy, and the necessity of repeated applications of a spur-crushing clamp. He discussed the difficulty of closing the colostomy in some cases and said that he believes that failure of the colostomy to remain closed is most often due to the insufficient crushing of the spur effected by other types of clamps. Dr. Watt's modification of the usual spur-crushing clamp consists essentially of the addition of a thin central blade which can be sutured to the adjacent loops of sigmoid at the time of operation, and which subsequently serves as a guide when the crushing element of the clamp is applied.

28. **Foy Roberson**, Durham, N. C., reported two cases of solitary cyst of the spleen. A personal case was of the true serous or lymphatic type. The other case, a hemorrhagic cyst, was under someone else's care. He classified cysts of the spleen into three types: hydatid, hemorrhagic, and lymphatic. In 646 splenectomies performed at the Mayo Clinic between 1900 and 1934, only 2 cases of cyst of the spleen were observed. Trauma, degenerative changes, or neoplasia may cause solitary cysts of the spleen. There is no constant dependable sign or symptom, but in the instance of large cysts a mass may be detected. X-ray examination revealed a large spleen in Dr. Roberson's case, and the radiologist suggested the diagnosis of cyst of the spleen. Many cysts of the spleen will be found to be amenable to nonsurgical treatment.

In discussing Roberson's paper, **Charles Gordon Heyd**, New York, N. Y., said that solitary cysts are not rare. He drew attention to the fact that normal

position for some time after meals, and eating late at night should be avoided. Appropriate doses of antispasmodics should be administered. In the case of obese patients, loss of weight often affords considerable relief. Dr. Guthrie discussed the occurrence of complications, such as ulceration of the esophageal mucosa, obstruction, hemorrhage, and cardiac failure. He advocates operative treatment if the diameter of the hernia is 5 cm. or more.

34. **Howard Mahorner,** New Orleans, La., spoke on umbilical and midline ventral hernias. He stated that, except for the size of the hernias and the shape of the opening, these types of hernias are very much alike. The incidence of umbilical hernias is greater in the negro than in the white population. Postoperative wound infection occurs less frequently, he stated, when silk is used as the suture material. The factors responsible for recurrence are: obesity, closure under tension, imperfect approximation, the type of suture material used, the type of operation employed, and infection. For preoperative preparation, Dr. Mahorner advocates weight reduction, increasing abdominal pressure with binders, cardiac and urinary studies, and supportive therapy. He advised two-stage operations for the large irreducible hernias, and advocated the introduction of transverse fascia strips between the linea semilunares to relieve tension on the suture lines.

In discussing this paper, **Bradley Coley,** New York, N. Y., recommended a longer period of preoperative care and preparation, sometimes keeping the patient in the Trendelenburg position. He administers pitressin for seventy-two hours preoperatively to reduce distention. Dr. Coley also felt that the use of silk reduces the incidence of recurrence. **Isidore Cohn,** New Orleans, La., believes that epigastric hernias are more frequent than is indicated in most statistics. He has been using a rectus sheath overlap operation for the past seven years. **Charles R. Robins,** Richmond, Va., suggested the use of a sling to relieve tension at the time of operation.

Rudolph Matas, New Orleans, La., demonstrated the case of a 44-year-old man with a very extensive venous hemangioma with pachydermal skin on the right hand. The lesions involved practically the entire right arm, forearm, and hand, the right chest wall and, to a lesser extent, the lower part of the left arm and upper part of the left forearm.

36. **Bradley L. Coley,** New York, N. Y., reported two cases of caisson disease, with special reference to the bone and joint lesions. He said that Erdman and Phemister are about the only others who have reported such cases. This disease is one of the unusual nonmalignant diseases of the osseous system. He reviewed the ancient history of caisson disease, and traced the development of diving suits and helmets. He discussed the retardation of nitrogen elimination from the spinal cord and the bones, a phenomenon which makes these structures particularly susceptible to the increased nitrogen tension caused by increased atmospheric pressure. Long bones are more likely to be involved than are the flat ones. Massive necrosis of the femoral shaft due to caisson disease simulates pyogenic osteitis and may be associated with deforming arthritis. He discussed the differential diagnosis and considered the workmen's compensation aspects of these lesions. Dr. Coley then reported two cases of caisson disease which he had observed in men who had worked as sand hogs.

In discussing the paper, **Isidore Cohn,** New Orleans, La., said that the bone changes present in Garré's disease or sclerosing osteitis are similar to those which he observed in the x-rays demonstrated by Dr. Coley.

39. **Frank L. Barnes,** Houston, Tex., reported a case of granulosa cell tumor of the ovary. About 300 cases are now on record. The presence of these tumors can be recognized preoperatively by the manifestations of excessive estrin

the tongue may assist in the dissection. Extensive scarring and infection, related to previous operations, is an important factor in recurrence.

In discussing the paper, **Frank Lahey**, Boston, Mass, agreed that only radical operations give good results. He reported 200 cases with the same experiences as Dr. Pemberton. Dr. Lahey deprecated the making of a longitudinal incision in operations for thyroglossal fistula, because of the very undesirable cheek-rein scar which follows. He drew attention to the occasional development of squamous cell carcinoma in thyroglossal fistulas. Dr. Lahey then presented some of his observations in regard to lingual thyroids. He advocated removal of lingual thyroids by the oral route; advised the employment of intratracheal anesthesia; spoke about the importance of the proper placing of packs within the mouth; and recommended the introduction of traction sutures through the tongue. The possibility of myxedema occurring following the removal of lingual thyroids was mentioned. **Vilray P. Blair**, St. Louis, Mo., reported having removed part of a lingual thyroid.

31. **V. P. Blair**, St. Louis, Mo., reported the case of a child who had lost the tip of her middle finger. The distal phalanx and part of the middle phalanx of the second toe was grafted to the remaining portion of the finger with very good cosmetic effect and satisfactory functional results.

32. **H. L. Kirkham**, Houston, Tex., discussed the use of preserved cartilage in ear reconstruction. He emphasized the difficulty of patterning a rib cartilage graft that will be thin enough, and also referred to the difficulty of satisfactorily modeling the cartilage. He believes that transplanted cartilage remains permanently as cartilage. He considers a weak aqueous solution of merthiolate and saline solution to be the best preservative. The solution should be changed every week. By making several perforations through the cartilage, granulation tissue can extend through the perforations and thereby anchor the graft. Dr. Kirkham illustrated the operative procedure as follows: the cartilage is buried under a flap, the incision for which begins well up in the hair line above the ear and mastoid; the ear is raised and brought forward; a tube pedicle is made from the neck; the tragus is formed; the pedicle is transformed to form the helix. Following completion of the ear, the pedicle is returned.

In discussing this paper, **Vilray P. Blair**, St. Louis, Mo., commended Dr. Kirkham. He said that dead cartilage does not unite with tissue as does living cartilage. He thinks that ear repair for congenital deformities should be done by the time the child is 5 years old. **John S. Davis**, Baltimore, Md., is of the opinion that autocartilage is distinctly preferable, but that isocartilage may be used if necessary.

33. **Donald Guthrie**, Sayre, Pa., in reporting on the incidence and diagnosis of hiatal hernia, stated that at the Mayo Clinic, between 1932 and 1937, there were 267 such cases. He said that there is a general increase in the frequency with which the diagnosis is made. The important role played by the clinician in detecting symptoms and requesting x-ray examination in suspected cases was discussed. He outlined the various types of hiatal hernia: (1) the congenital short esophagus with partial or complete thoracic stomach, (2) the paraesophageal hernia, and (3) the sliding hernia with shortened esophagus. Hiatal hernia can usually be recognized with the patient in the recumbent position, but the hernia is not likely to be revealed if the patient is standing. An esophagoscope should be used in those cases in which hemorrhage has occurred, to determine whether the bleeding is the result of carcinoma, ulcer, or hiatal hernia. Not all cases require surgical treatment. When operative repair of the defect is not considered necessary, or safe, the patient should eat small meals and remain in the upright

REPORT OF THE FORTY-NINTH ANNUAL MEETING OF THE WESTERN SURGICAL ASSOCIATION, LOS ANGELES, CALIF., DEC. 15 AND 16, 1939

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THE forty-ninth annual meeting of the Western Surgical Association was held in Los Angeles, Calif., Dec. 15 and 16, 1939. **Vernon David,** Chicago, Ill., President of the Association, acted as chairman of the meeting. **Alfred Brown,** Omaha, Neb., was elected president for 1940. The place selected for the next meeting was Topeka, Kan.

The local committee had arranged an interesting program of operative and non-operative clinics at the Los Angeles County General Hospital which were held the day prior to the formal opening of the meeting. The following brief abstracts are compiled from the notes taken by three of us, **C. B. Puestow,** of Chicago, Ill., **W. R. Lovelace, II,** of Rochester, Minn., and myself, at the time of presentation of the papers. For any inaccuracies in reporting, apologies are herewith made.

CLINICS AT THE LOS ANGELES COUNTY GENERAL HOSPITAL

H. E. Schiffbauer, Los Angeles, Calif.: **Diaphragmatic Hernia.**—Eleven cases (those of 9 men and 2 women) of traumatic diaphragmatic hernia were reported, all of which were the result of automobile accidents and in all the hernia was on the left side. The symptoms in these cases had been of a few weeks' to ten years' duration. Pain which extended to the shoulder was an important symptom; fractured ribs and injuries to the lower part of the thorax and upper part of the lumbar region should be looked for. The patient is not placed in shock position, even though he is in shock, but a semi-Fowler position is employed. A Levine tube with suction is used; oxygen is used whenever indicated. Operation is not undertaken when the condition is in the acute phase, except when necessary to stop hemorrhage or perforation. A transpleural approach is employed in the chronic case or in the chronic case which has become acute. Occasionally the phrenic nerve is crushed as it enters the diaphragm; it regenerates in only three to four months. Holes are punctured in the ends of the ribs in order to facilitate tying them back together.

C. J. Berne, Los Angeles, Calif.: **Arterial Embolectomy.**—At the Los Angeles County Hospital, the ratio of embolic to thrombotic obstructions is 5 or 6 to 2. In the typical case of thrombophlebitis, a white, cold, painful, and tender leg may result from arterial spasm. In the first one or two hours, tenseness caused by edema often may be detected on palpation of the calf of the leg. Unless there is a propagation thrombosis, there may be shunting of the blood below the embolic lesion. In these cases the cold level is lower than would be expected. The patient is placed in the dependent position. No heat is applied because it increases the oxygen consumption of the tissue, thus favoring gangrene. Heat is applied to other parts of the body. The pavex machine is not used in cases of femoral obstruction because it cuts off collateral circulation. Papaverine may be of help. Injection of the sympathetic nerves with procaine hydrochloride (novocain) has not been very successful. Ligation of the saphenous vein was

Received for publication, February 5, 1940.

secretion. In children, granulosa cell tumors cause the precocious development of secondary sex characteristics. In young adults, the diagnosis is most difficult and sometimes is evidenced only by an increased menstrual flow. The occurrence of these tumors after the menopause may cause a recurrence of menstruation. Periods of menorrhagia may be interspersed with periods of amenorrhea. In the case which Dr. Barnes illustrated, menses ceased at 40 years of age and reappeared when the patient was 54 years old. Granulosa cell tumors may be associated with other tumors of the ovary and may occupy either part or all of the ovary. A solid tumor of the ovary, removed by **Albert O. Singleton**, Galveston, Tex., was also reported by Dr. Barnes.

40. **Thomas D. Sparrow**, Charlotte, N. C., presented a paper on leucoplakic vulvitis. He reviewed the history of the description of this condition. There has been much confusion in respect to nomenclature, probably because of varying opinions concerning its cause and the various manifestations in its different forms. The theories of etiology were reviewed, but the inadequacy of those so far advanced was pointed out. The primary hypertrophic phases with acanthosis are often followed by an atrophic phase with associated collagenous changes. It is a disease of the menopause or postmenopause. The disease is important because it is a precancerous condition, and malignancy at the time of operation was observed in about 50 per cent of the cases. About 36 per cent of patients with carcinoma of the vulva give a history of preceding leucoplakia. Differential diagnosis must be made between leucoplakia, lichen planus, scleroderma, syphilis, fungus dermatitis, etc. Local applications as a form of therapy are worthless. The various combinations of treatment which have been employed include the administration of hydrochloric acid, vitamin A, sex hormones hypodermically in solution or in pellet form as well as by local application and in the form of vaginal suppositories, and x-radiation. Surgical extirpation is often necessary or advisable. He then reviewed the various methods of excision and plastic repair which have been devised. He has observed postoperative persistence of pruritus or skin changes in a number of cases.

In discussing Dr. Barnes' paper, **Samuel L. Ledbetter**, Birmingham, Ala., cited a case of arrhenoblastoma which he had observed and presented this case as a counterpart to the granulosa cell tumor. A tumor the size of a grapefruit in the right ovary was found at operation. A tumor of undetermined histology, attached to the left tube, was also removed at the same time. Menstruation was re-established, voice changes were relieved, and a general return to feminine from masculine characters occurred. **Albert O. Singleton**, Galveston, Texas., stated that his case of tumor, referred to by Dr. Barnes, was removed incidentally, in the course of an operation for rectal prolapse.

his method of using a Smith-Petersen nail. His technique was illustrated in a motion picture.

B. O. Raulston and H. J. Magnuson, Los Angeles, Calif.: **A Demonstration of the Use of the Spectograph in the Analysis of Biological Material.**—The apparatus described was made practical by the use of a photoelectric cell with a controlled current. The authors employed a grading spectograph with 20,000 lines to the inch. They can determine the amount of silver in the body in cases of argyrol poisoning, as well as the amount of lead and bismuth in poisoning caused by these metals. They plan to study the distribution of minerals in the body, as, for instance, in the treatment of syphilis.

George Thomason, Los Angeles, Calif.: **Massive Resection for Extensive Intestinal Adhesions: Four Cases.**—The case of a woman who had undergone fifteen previous laparotomies and who had obstruction of the proximal portion of the ileum was reported. Resection was made of 5 feet (152 cm.) of jejunum and an end-to-side jejunogastrostomy was performed. Another patient suffered from an inflammatory mass in the right lower quadrant of the abdomen. Resection was made of 4 feet (122 cm.) of the terminal part of the ileum and the right half of the colon. An ileocolostomy between the ileum and transverse colon was performed. The third case was described as similar to the previous one; the condition was believed to be the result of a previous appendectomy. The same procedure as that described in the preceding case was performed. The fourth case was that of a woman who gave a history of six previous laparotomies and now had high intestinal obstruction. At operation the duodenojejunal junction was found to be on the right side and surrounded by a mass of adhesions. The adhesions were freed and a side-to-side enteroenterostomy was performed.

H. K. Bonn, Los Angeles, Calif.: **Review of 1,000 Gall-Bladder Operations.**—Sixteen patients were operated upon within forty-eight hours of the onset of symptoms of acute cholecystitis, with a mortality of 19 per cent. Sixty-four patients were operated upon between forty-eight hours and seven days after the onset of symptoms with a mortality of 7.8 per cent. The mortality in 427 cases which came to operation more than six days after the onset of symptoms was 5.4 per cent. The ratio of acute disease was about the same in men as in women, but more women had subacute cholecystitis. Dr. Bonn discussed the series of Drs. Hevers, Judd, Phillips, and Pennoyer.

A. C. Pattison, Los Angeles, Calif.: **Injection Treatment for Acute Thrombophlebitis.**—Injection of the lumbar sympathetic nerves with procaine hydrochloride (novocain) stops arterial spasm, prevents propagation thrombosis, and the increased blood supply prevents lymphatic blockage. In 11 cases in which this treatment was used, excellent results were obtained in 5 with complete disappearance of edema. In 3 cases, pain and tenderness only were relieved, but the course was the same. In 3 cases the symptoms ceased and there was only slight edema when the patient was in an upright position. In the favorable cases, the swelling diminished in twenty-four hours and was gone in ten days. The skin temperature at the toe was increased 2 to 8° F. after injection. A trial injection of papaverine first in all cases was recommended.

REGULAR MEETING

Edmund Andrews, Bloomington, Ill.: **Blood Ether Levels in Surgical Anesthesia.**—The author described a new method by which the amount of ether in blood may be determined in about fifteen minutes with an accuracy of 2 per cent. An exceedingly wide range of levels of ether in the blood was noted among dif-

advised in the late cases. Thirty-one cases were reported; 30 of the patients were seen less than twelve hours after onset of symptoms. Embolectomy from femoral, brachial, and axillary arteries had been performed.

L. T. Bullock, F. S. Dolley, and J. C. Jones, Los Angeles, Calif.: Ligation of Patent Ductus Arteriosus.—In a careful review of 80 cases, it was found that 85 per cent of the patients died as a result of cardiac lesions, endocarditis, cardiac failure, and so forth. The symptoms described were continuous murmur in the second or third interspace, increased pulmonic second sound present in 8 of the 11 patients who were presented, prominent conus arteriosus, increased pulse pressure, lowering of diastolic blood pressure with exercise, which will give signs of aortic insufficiency, femoral sound, absence of cyanosis, and absence of axis deviation of the heart. There was a thrill in 9 of the 11 cases, which extended into diastole. At operation the approach is made through the second interspace. Intratracheal anesthesia is used and the lung is inflated about every ten minutes in order to avoid atelectasis. Care is taken to avoid the recurrent laryngeal nerve at the junction of the duct with the arteries. Practically all the symptoms disappeared postoperatively, and at the time of this meeting the patients had made satisfactory progress.

P. M. Wood, New York, N. Y.: Experimental Work With Trichlor-Ethanol Basal Anesthesia.—This agent is liquid, slightly ethereal in odor; it is heavier than avertin and there are 1,555 mg. in 1 c.c. In a series of 700 cases, Dr. Wood found frequent extrasystoles and arrhythmias, especially during induction and awakening. The pulse rate did not rise as high as on the use of avertin. The respiratory rate and volume exchange were higher than those noted with the use of avertin and the central nervous system is more excited with its use than with the use of avertin. The patient's color may become oyster white.

In discussion, **C. D. Leake**, Professor of Pharmacology of the University of California, emphasized the need for careful study of anesthetic agents and for consultations between the pharmacologists and anesthetists.

W. Baker, New Orleans, La.: Resuscitation (Acute Asphyxia).—In this condition a vicious cycle soon is reached in which anoxia causes paralysis of the respiratory center. Dr. Baker sees no need for administration of carbon dioxide, because in most cases there is an excess of carbon dioxide in the circulating blood. In deep asphyxia, he stated, positive pressure usually is necessary because of the loss of muscle tone, and Schäffer's method and other methods of artificial respiration do not give the necessary exchange of air. He expressed the belief that only 150 c.c. of air is forced in and out in this way, and this quantity represents only the dead space air. Mouth-to-mouth insufflation, it is believed, is excellent. Pharyngeal obstruction can be overcome by positive pressure.

E. H. Warnock, Los Angeles, Calif.: Oxygen Therapy.—The need for early administration of oxygen before the patient is moribund was emphasized. Increased elevation of temperature increases the demand for oxygen. Oxygen is given to patients with cardiac lesions when an acute condition is superimposed on a chronic one. In three hospitals in which oxygen tents were used, the average concentrations of oxygen were found to be only 22 to 28 per cent, which would be of practically no value. In pneumonia there is an increase in lactic acid as the result of anoxemia. Dr. Warnock discussed the use of the Boothby-Lovelace-Bulbulian inhalation apparatus for the administration of either high or average concentrations of oxygen or mixtures of helium and oxygen.

V. P. Thompson, Los Angeles, Calif.: Intracapsular Femoral Neck Fractures.—The author discussed those cases in which open reduction was necessary and then

his method of using a Smith-Petersen nail. His technique was illustrated in a motion picture.

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ferent patients which indicated individual susceptibility. Venous samples of blood were taken in the second stage of anesthesia, before the operation had been started. Essentially the same levels of ether were noted in the blood of patients who had not received morphine preoperatively and those who had received morphine preoperatively. Morphine *does not* appreciably reduce the time or increase the ease of induction and often obscures the signs of anesthesia.

In discussion, **W. D. Gatch**, Indianapolis, Ind., stated that, when an apparatus similar to a drunkometer was used, ether was found in blood for as long as twenty hours after narcosis.

J. D. **Bisgard**, Omaha, Neb.: **The Influence of Certain Commonly Employed Therapeutic Procedures Upon Gastric and Intestinal Tone and Motility.**—A Miller-Abbott tube, with a connection to a U-shaped manometer and kymograph, was passed after the patients tested had been *fasting*. A thirty-minute normal record was taken. When a cold pack is applied to the abdomen, secretion of hydrochloric acid increases. Application of a hot pack causes inhibition of peristalsis and lessening of tone. Oral administration of hot water causes vigorous peristalsis. No effect or inhibition was noted after the oral administration of ice water. Hot packs on the thighs had little effect, but cold packs increased the peristaltic activity of the stomach and also increased the quantity of hydrochloric acid in the stomach. Horton and Brown stated that cold applied to the body releases histamine. The motility was not measured and so it may be that cold packs producing only peristalsis may not always be indicated. It is believed that the application of heat to the abdomen and the ingestion of warm water is indicated in the treatment of inflammatory lesions and bleeding ulcers when a sedative effect is desirable, and that ice packs and the ingestion of cold water, rather than the use of heat, are indicated for the relief of distention or conditions in which a stimulating or motor effect is desirable.

In discussion, **A. J. Brown**, Omaha, Neb., brought out the point that these studies were made mostly on normal subjects and that in appendicitis, also, cold packs may increase peristalsis and keep up tone rather than keep the bowel at rest. **H. H. Davis**, Omaha, Neb., stated that in an old study he had found that spinal anesthesia slowed up the elimination of barium. **C. A. Roeder**, Omaha, Neb., said that the level of acid in his stomach was low when he was in a hot country.

C. A. Nafe, Indianapolis, Ind.: **Reversed Intestinal Rotation: Case Report.**—The patient, aged 8 years, had a history of vomiting, pain beneath the umbilicus, inability to take food for nine days, and obstipation of four days' duration. He had had similar attacks intermittently since he was nine days old. Exploratory operation revealed reversed rotation of the large bowel, the transverse colon passing posterior to the superior mesenteric vein and artery. However, the duodenum passed through the mesocolon, to the right of the midline, and was not anterior to the transverse colon, as is usually the case. The veins of the mesentery were considerably dilated and moderate mesenteric lymphadenitis was present. A case of hernia of the small intestine into a mesenteric sac also was reported. This patient died fifteen hours after operation.

In discussion, **C. J. Hunt**, Kansas City, Mo., stated that the anatomy of the peritoneum in the cat is the anatomy of the human embryo before rotation occurs.

G. C. Penberthy, Detroit, Mich.: **The Treatment of Adynamic Ileus in Children.**—Adynamic ileus in children apparently is neurogenic in origin and represents a condition and aggravation of physiologic paralysis of intestinal motility which follows opening of the peritoneum and results from several causes. Mortal-

ity is likely to be higher among children than among adults because the former cannot withstand distention, loss of fluids, and an abnormal chemical balance as well as can adults. Methods of treatment include (1) prophylaxis, (2) enemas and local applications, (3) drugs, and (4) enterostomy (seldom). The most logical treatment is removal of the distention and gas by means of intubation with a balloon type of tube and the administration of oxygen with the B.L.B. inhalation apparatus. Illustrative cases were presented.

In discussion, **C. F. Dixon**, Rochester, Minn., stated that he often clamps and unclamps the tube intermittently.

Lawrence Chaffin, Los Angeles, Calif.: **Surgical Emergencies During Childhood Caused by Meckel's Diverticulum.**—Analysis had been made of 18 cases of laparotomy on children occasioned by Meckel's diverticulum. The group of cases included 16 boys and 2 girls. The symptoms of Meckel's diverticulum are so similar to those of appendicitis that a preoperative diagnosis rarely is made. Secondary anemia is suggestive of the condition, but roentgenologic examination is not of much help. The duration of symptoms in this group varied from a few hours to one year. Periodic anemia and slight rise in temperature should be watched as indications of the presence of Meckel's diverticulum. One diverticulum was 38½ inches (96 cm.) long and was situated in the mesentery parallel with the ileum so that it was necessary to resect the terminal portion of the ileum. In one case the diverticulum extended out to and through the umbilicus and a fecal fistula was formed. In another case, the diverticulum projected out of the ileum and had an external opening at the umbilicus with atresia of the midportion of the diverticulum into a fibrous band. The portion of the diverticulum which opened into the umbilicus contained a small ulcer; the gastric mucosa formed the lining of the diverticulum. Dr. Chaffin stated that, in order to avoid future bleeding, all of the diverticulum must be excised. Complications associated with Meckel's diverticulum include perforation, intussusception, peritonitis, volvulus, and intestinal obstruction.

H. L. Kretschmer, Chicago, Ill.: **Diverticula of the Urinary Bladder.**—There were 229 men and 6 women in the group of cases discussed, most of the patients being between 40 and 80 years of age. Most of the men had, in addition to diverticulum of the bladder, benign hypertrophy of the prostate gland. Practically all the patients had some type of obstruction. Tumors, as well as stones, occasionally were found in the diverticula, so it is well to watch for shadows near the brim of the pelvis in roentgenograms. A diverticulum situated near a ureter may cause renal damage. Routine removal of the diverticula is no longer performed, inasmuch as complete relief of obstruction often results in decrease in the size of the diverticulum. Patients with this condition should be watched and checked over for infection.

Thomas Joyce, Portland, Ore. (Guest Speaker): **Periarteritis Nodosum.**—The ratio of males to females suffering from this condition is 4:1. Until 1938, 214 cases had been reported in the literature; the condition occurs chiefly in the third decade of life. It is found in muscular arteries and arterioles; renal, mesenteric, coronary, hepatic, visceral, and cranial arteries. Nodules and an occasional aneurysm appear along the artery. There is degeneration of muscular fibers of media with necrosis, causing aneurysm, thrombosis, and fibrosis. There are four stages: degeneration, inflammation, necrosis, and scarring. The symptoms include Meyer-Brinkman triad, fever, general weakness and loss of weight, albuminuria, polyneuritis, skin lesions, and cardiac signs. The course of the disease is from three to four months. Termination usually is due to cardiac failure, marasmus, or local vascular accidents.

Urban Maes, New Orleans, La.: **Diabetic Gangrene: Mortality Factors.**—(This paper was presented by **H. C. Ilgenfritz**, New Orleans, La., the co-author.) A review was made of all cases of diabetic gangrene in which treatment had been given in the past six years at the Charity Hospital of Louisiana at New Orleans. Use of insulin has increased the number of diabetic patients who are at the age to have vascular disease. From 1934 to 1939, inclusive, 126 patients were seen, 57 of whom died. Ninety-eight of the 126 were operated upon with 45 deaths. There were 31 men and 95 women; 54 were white patients and 72 were colored. Moist gangrene was the common form of the disease. The presence of cardiac reserve and renal efficiency of these patients must be determined and the internist and surgeon must work together. Cellulitis is better treated conservatively than with incision and drainage. Moist gangrene prohibits local operation. Amputation is better delayed only for stabilization of the diabetes. Extension of gangrene is the chief cause of death; cardiovascular disease and arteriosclerosis are the next chief causes of death. Of the patients who die, 7 per cent have diabetic coma. In the care of these patients, glucose and insulin are administered; a cradle is used without light or heat, and the affected part is not elevated. Spinal anesthesia is administered, but a tourniquet is not used. Circular amputation without any flap is best, with loose closure and no drainage.

In discussion, **C. L. Callander**, San Francisco, Calif., stated that in cases of gangrene which he had followed, whether the condition was due to diabetes, arteriosclerosis, or other causes, in an early series of 157 cases, amputations through the thigh were performed with a mortality of 57 per cent; in a recent series of 125 cases, a tendoplastic amputation at the knee was performed, the technique of which he described, with a mortality of 15 per cent.

Kellogg Speed, Chicago, Ill.: **Hip Arthroplasty: Use of Vitalium Cap.**—Two cases were reviewed. The author described the technique by which he loosely applied a vitalium cap over the head of the bony ankylosed femur, after it had been freed up. The vitalium cap is not affixed to the head of the femur and, so far, atrophy or absorption has not occurred. He has not found it necessary to remove the cap as yet. Roentgenologic findings before and after the operation were presented.

Fred Christopher, Winnetka, Ill.: **Ambulatory Treatment of Impacted Hip Fracture.**—Five cases were reported in which there were impacted fractures of the neck of the femur with union and complete recovery following treatment by a short abduction spica cast, a 2-inch lift (5 cm.) on the shoe for the foot on the well side, and walking with crutches in a few days. Casts were left on for thirty to forty-five days. All cases were followed up for one year.

In discussion, **E. L. Gilcreest**, San Francisco, Calif., stated that he believed pinning was better in the hands of the average surgeon. He pointed out that in the cases reported all the fractures were impacted and none was of the shearing type. **F. E. Clough**, San Bernardino, Calif., mentioned that he uses Anderson's method of well-leg traction splint and is not in favor of metal in all fractures of the neck of the femur. **J. A. Jackson**, Madison, Wis., stated that he favors internal fixation with a nail. Blind nailing of reduction can be made; otherwise, open.

Earl C. Padgett, Kansas City, Mo.: **Osteomyelitis of the Jaw.**—Fifty-nine cases were reviewed. Extraction of teeth and infected teeth were the chief causes of the condition; other causes are sinus infection, trauma, mercury poisoning, leucemia, corrosive fluid, and blood-borne infections. Streptococci are the usual organisms found. Teeth and tooth buds act as foreign bodies and so influence

infections. The mandible is more often affected than the maxilla. The clinical course of the disease is characterized by pain, swelling, and bulging. In the acute phase of the disease, treatment should be conservative, but, after sequestration has occurred, radical treatment, including removal of the sequestrum, is most effective.

In discussion, **E. L. Gilcreest**, San Francisco, Calif., stated that, when osteomyelitis accompanies fracture of the mandible, if the teeth are accurately wired whenever possible and the wound is kept clean with Dakin's solution, the gap often will fill and heal well. **E. D. Twyman**, Kansas City, Mo., spoke of a group of cases in which osteomyelitis follows radical operation carried out with cautery.

R. M. Carter, Green Bay, Wis.: **Chondroma of Bone: Report of Unusual Case.**—A case of multiple enchondromas of an entire lower extremity, together with involvement of the pelvic bones, was presented. Because of persistent and severe pain, as well as the deformity itself, amputation of the entire lower extremity was carried out. On microscopic examination there was no evidence of malignancy. Very good roentgenograms of the lesion were shown.

In discussion, **Kellogg Speed**, Chicago, Ill., described some of the deformities found which caused gargoylism.

James A. Jackson, Madison, Wis.: **Total Gastrectomy for Linitis Plastica, With Case Report.**—In 1933, approximately 88 cases of successful total gastrectomy had been reported, but Dr. Jackson does not believe that in all these cases the pyloric and cardiac sphincters were removed as well as the entire stomach, which is necessary if the operation is to be called total gastrectomy. The case reported was that of a woman, 69 years of age, who had had symptoms referable to the stomach for five months. On roentgenologic examination of the stomach, a diagnosis of linitis plastica was made, which was confirmed by operative findings and microscopic examination. Total gastrectomy and a posterior Polya esophagojejunostomy (isoperistaltic) were performed, the Dixon right-angled colon clamp being used.

In discussion, **Verne Hunt**, Los Angeles, Calif., reported two cases of total gastrectomy; one of the patients lived. **C. A. Roeder**, Omaha, Neb., stated that he had looked up the literature and found that 44 of the 88 patients whose cases were reported survived.

Angus L. Cameron, Minot, N. Dak.: **Sarcoma of the Stomach.**—Two cases of sarcoma of the stomach of a relatively low grade of malignancy which were found among 135 instances of gastric malignancy were reported. Dr. Cameron stated that the degree of malignancy of spindle-cell sarcoma was low. The literature for the past ten years was reviewed.

In discussion, **Verne Hunt**, Los Angeles, Calif., stated that he had had two patients, a boy aged 3 years and a girl 8 months old, who suffered from lymphosarcoma for which he had performed partial gastrectomy. The boy is 11 years old now and quite well. The case of another patient, a physician, was presented who had derived an excellent result from roentgen therapy alone.

S. R. Maxeiner, Minneapolis, Minn.: **The Present Surgical Management of Esophageal Diverticula With Presentation of a New (?) Method.**—An operation was described by means of which the base of the diverticulum is freed up and a curved forceps is applied, after which the diverticulum is cut off with cautery and a cuff is sewed over the clamp. The clamp is left on until it sloughs off; this usually requires about six days. A case was reported in which this method of treatment had been used successfully and several experimental procedures of

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cyst is found to have completely disappeared at a second operation. Dr. Meyer feels that the contents of the cyst are absorbed by the mucosa of the gall bladder because equally good results were obtained whether or not the cystic duct was ligated.

In discussion, **J. D. Bisgard**, Omaha, Neb., stated that he felt that the cystic duct never should be closed because the gall bladder might fibrose from the action of the pancreatic juice and then would be unable to absorb the contents of the cyst.

Cuthbert Powell, Denver, Colo.: **Granulosa-Cell Tumor of the Ovary.**—Granulosa-cell tumors make up approximately 12 per cent of all ovarian tumors and are almost always found in the ovary. Dockerty's recent study was quoted. Complete removal of the tumors rarely is followed by recurrence. One patient gave a history of seven miscarriages.

O. F. Lamson, Seattle, Wash.: **Multiple Primary Carcinoma.**—At all operations for carcinoma, a careful search should be made for multiple lesions because the fact that a malignant growth is present indicates that the patient is susceptible to cancer. The literature was reviewed. One of Dr. Lamson's patients had malignant polyp of the colon and later carcinoma of the breast was found. Another patient had papillary adenocarcinoma of the ovary, as well as carcinoma of the cecum. The latter had obstructed the appendix which, in turn, had become inflamed. A Mikulicz type of resection and an ileostomy were performed.

REPORT OF THE TWENTY-FIFTH ANNUAL MEETING OF THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

C. N. Borman, M.D., Minneapolis, Minn.

(From the Department of Radiology, University of Minnesota)

PAPERS of interest to the surgeon presented at the twenty-fifth annual meeting of the Radiological Society of North America held in Atlanta, Ga., Dec. 11 to 15, 1939, were as follows:

Milton Friedman, New York, N. Y., described a new applicator for use in radium treatment of carcinoma of the corpus uteri. This applicator, termed by the author, the hysterostat, permits fixation of the radium capsules inside the uterine cavity in such a manner that in practically any size or shape of cavity a fairly even distribution of radium emanation is effected. A hinged capsule holder which is attached to a metallic rod can be inserted through the cervical canal in a position parallel to the rod, and later, when in the cavity, rotated to a position at right angles to the rod. Doses ranging from 4,000 to 7,700 mg. hr. of radium have been applied. Films of the pelvis made after radium insertion to show the distribution of radiation intensity indicate an improvement over the conventional methods of application. It was shown that in cases wherein the uterine cavity was deformed by tumor masses an effective distribution of radiation intensity to all parts of the cavity could be obtained. In seven of eight cases having had hysterectomies following this type of radium application, histologic examination revealed no evidence of viable carcinoma cells.

Lowell S. Goin and **Eugene F. Hoffman**, Los Angeles, Calif., described a new approach to treatment of certain types of carcinoma of the urinary bladder. Direct

Received for publication, Jan. 5, 1940.

a like nature which had been carried out on dogs were described. This method was advocated because it can be performed in one stage and there is little chance of infection.

In discussion, **R. W. McNealy**, Chicago, Ill., stated that he felt all diverticula of the esophagus could not be treated in this manner.

C. W. Mayo, Rochester, Minn.: **Malignant Lesions of the Cecum and Right Half of the Colon.**—An analysis has been made, both general and specific, of a series of 885 consecutive cases with special reference to the mortality after various types of operation for resection of the right half of the colon, both of one-stage and two-stage varieties. The advantages and disadvantages of each were discussed. An analysis also was made of the factors involved in prognosis, both immediate and distant, in malignancy of the right half of the colon.

J. W. Duncan, Omaha, Neb.: **Hernia of the Large Intestine.**—Six cases of true sliding hernia of the large intestine were reported. The diagnosis usually is not made until the time of operation, which makes the danger of the injection therapy obvious. Dr. Duncan advised early surgical intervention in nonreducible hernias and has found it best not to retroperitonealize the gut routinely when it is freed up. The pathologic anatomy of this condition was reviewed.

A. N. Collins, Duluth, Minn.: **Fecal Fistula Following Appendicitis.**—Study of eighteen cases of fecal fistula in Duluth hospitals was reported; in all the condition was serious and in 61 per cent gangrene occurred. Dr. Collins advocated inversion of the stump.

The discussors of this paper emphasized the necessity of being on the lookout for tuberculosis, actinomycosis, and so forth.

V. C. David, Chicago, Ill.: **Presidential Address.**—The rather wide prevalence of fee splitting was discussed. In connection with the Wagner National Health Bill, Dr. David is against state public health officials being in power because of the danger of too much politics. He advocated a cabinet officer to be concerned with health and veterans. He also advocated a nonpolitical, nonprofit project for the indigent and for the low-income group (0 to $1,500 or $2,000). He feels that others are well cared for now. It is his opinion that laymen should be represented on hospital boards.

C. J. Hunt, Kansas City, Mo.: **Diagnosis and Surgical Removal of Substernal and Intrathoracic Goiters.**—The author stressed the necessity for adequate roentgenologic investigation to determine the position and depth of the lesion and the necessity for lateral as well as anteroposterior roentgenograms to determine the relative position of the trachea. He uses local block and infiltration anesthesia and intratracheal anesthesia whenever advisable, with a mixture of helium and oxygen. He advised the use of a large, low-collar incision; ligation of the superior thyroid arteries first; clamping of blood vessels from above downward; and care not to produce a vacuum when elevating the gland, as the blood vessels are thin and friable. He uses a posterior approach.

In discussion, **C. A. Nafe**, Indianapolis, Ind., stated that the roentgenograms do not always give positive evidence of goiter, even when one is present. He advised checking the vocal cords before operation.

K. A. Meyer, Chicago, Ill.: **Internal Drainage of Pancreatic Cyst.**—Internal drainage of unresectable pancreatic cysts has been advocated in preference to external drainage in order to avoid prolonged draining of abdominal wounds and not infrequent secondary infection of the cysts. He advocated freeing the gall bladder from its bed and then anastomosing it to the pancreatic cyst. The

Duodenal ulcer was the most frequent cause of hemorrhage. Although massive hemorrhage occurs with equal frequency before and after 45 years of age, 96 per cent of the deaths from massive hemorrhage occurred in patients over 45 years of age. Since only 4 per cent of patients under 45 years die from massive hemorrhage, the authors pointed out that surgical intervention in young people is rarely justified. On the other hand, in patients over 45 years of age prompt surgical procedures may save many lives.

An average fourteen years' follow-up of 64 cases of duodenal ulcer receiving surgical treatment alone indicated that 86 per cent had obtained satisfactory relief and in 14 per cent the response was unsatisfactory; whereas, in 77 cases receiving medical treatment alone 65 per cent obtained satisfactory relief, and in 35 per cent the relief was unsatisfactory.

In the entire series the same clinicians and roentgenologist attended these patients.

A Symposium on Acute Intestinal Obstruction was participated in by a number of essayists. The experimental and clinical observations which bear upon the diagnosis and management of acute intestinal obstruction were detailed by **Owen H. Wangensteen**, Minneapolis, Minn. He emphasized the necessity for intimate correlation of the roentgen and clinical findings in order to arrive at a rational therapeutic procedure in all acute abdominal states. When this is done, it is possible to determine definitely whether the bowel is obstructed, whether the obstruction is simple or strangulating, complete or incomplete, and approximately in what portion of the intestinal tract it is located. The exact location is frequently impossible to determine and the manner in which the bowel is obstructed is also unrevealed without operation. **James E. Lofstrom**, Detroit, Mich., described the procedure of intubation with the Miller-Abbott tube and the value of this procedure in the diagnosis and localization of obstructive processes in the small intestine. Numerous cases of inflammatory, tumorous, and gallstone obstructions were demonstrated to illustrate the utility of intubation, with decompression, followed by roentgen examination, as a means of delineation of the obstruction. Roentgen studies of the small intestine with the Miller-Abbott tube were described by **Ross Golden**, New York, N. Y. He emphasized the necessity for deflation of the stomach before attempting to pass the tube through the pylorus and the importance of patience and exacting technique in passing the tube to the point of obstruction. After the intestine has been deflated, a small amount of barium sulfate suspension is injected through the tube, making it possible to delineate clearly the exact point and the exact nature of the obstructive process. He demonstrated a number of cases in which the differentiation of mechanical from paralytic ileus was made. The changes in the bowel occasioned by adhesive bands were described.

Leo G. Rigler and **Oscar Lipschultz**, Minneapolis, Minn., discussed **Roentgen Observations on Acute Obstruction of the Colon**, emphasizing especially the value of abdominal films, without contrast, in determining the presence, location, and nature of an obstructive process in the large bowel. The diagnostic criteria which permit a definite diagnosis of acute volvulus of the sigmoid colon were detailed. The authors also presented a new sign of acute perforation of the colon following obstruction; namely, the observation of the outer as well as the inner wall of the bowel in roentgenograms of the abdomen made with the patient supine.

Roentgen Ray Studies on Some Individuals Suffering From Low Back Pain was discussed by **Joseph Bell**, Louisville, Ky. He described a large number of cases in which multiple lesions of the spinal canal were present. In some

contact therapy is employed after marsupialization of the bladder. A midline cystotomy is employed, and, after closing of the space of Retzius, a drainage tube is left in place until the ninth or tenth postoperative day. A low voltage therapy tube, covered by sterile rubber stockinet, is used; the distance from the target to the tumor surface is only 22 mm. so that a very high r. output is obtained. The tumor is treated on alternate days, and doses as high as 30,000 r. over a period of twenty-seven days have been given. No formal presentation of results obtained was given, but favorable results are indicated from observation of the cases treated.

Edmund P. Halley, Decatur, Ill., reported on his experiences with preoperative irradiation of breast carcinoma. Microscopic study of the treated carcinomatous breasts indicated two types of damage to carcinoma cells: (1) primary necrosis of the more sensitive cells, and (2) mutational changes evidenced by giant-cell-like areas which undergo calcification. Tumor-bed changes are negligible when protracted irradiation is used. The author does not favor a short preoperative course since the maximal damaging effect on cells is not obtained in this manner. Therefore, the preoperative irradiation is carried to a full second-degree erythema reaction in a period of about four weeks, treating the breast and gland-bearing areas. Surgical removal is effected as soon as desquamation is complete, and in most of the reported cases the operation was performed within two to four weeks following completion of irradiation. Surgery should not be delayed beyond four weeks, after which time cancer cell regrowth is probable.

L. W. Paul, Madison, Wis., presented four cases of solitary or plasma cell myeloma of bone. This solitary, medullary, destructive lesion of bone must be differentiated from giant-cell tumor, since the resemblance is often striking. At times, the tumor may also simulate localized cystic disease of bone. Surgical removal of this type of lesion is very rarely justifiable, since recurrences take place, and the disease often develops into the better known generalized type, multiple myeloma. In small lesions of an extremity curettage followed by roentgen radiation therapy is advised. Lesions involving the spine or pelvis are best treated by roentgen irradiation alone.

W. Edward Chamberlain, Philadelphia, Pa., pointed out the importance of recognition of a developmental anomaly of the occipital bone and upper cervical vertebrae, termed platybasia or basilar impression. In this condition a stenosis of the foramen magnum is present, together with a cephalic bulging of the clivus and neighboring structures into the posterior fossa of the cranium. Pressure on the cord produces a train of symptoms very similar to those of syringomyelia, disseminated sclerosis, or various types of spastic paralysis. A considerable possibility of relief is offered these patients by surgical procedures correcting the cord compression. If all cases diagnosed syringomyelia are subjected to roentgen examination of the skull and cervical spine, it is quite probable that more cases of platybasia will be encountered.

Maurice F. Dwyer, John M. Blackford, and William S. Cole, Seattle, Wash., reviewed the clinical and roentgenologic aspects of 1,000 consecutive cases of peptic ulcer. The diagnosis in each case had been confirmed by careful roentgenologic and clinical studies. Especial attention was directed toward perforation and hemorrhage.

The highest incidence of perforation of both duodenal and gastric ulcers was in the age period of 30 to 40 years. Ninety per cent of duodenal ulcers perforated the anterior duodenal wall. In 82 cases of perforation 55 occurred during a quiescent period, while 27 cases perforated during a period of active symptoms. In the 82 perforated cases 4 had associated massive hemorrhage.

Book Reviews

Cancer: Its Diagnosis and Treatment. By Max Cutler, M.D., and Franz Buschke, M.D. Cloth. Pp. 757, with 346 illustrations. Philadelphia, 1938, W. B. Saunders Company. $10.

This monograph on malignancy written by two radiologists is essentially sound. The pathologic bases of their discussions are good and radiologists, as well as surgeons, in the main, would agree with their conclusions. The text is well annotated with references to pathologic, radiologic, and surgical sources of known merit.

The statement of the authors that attempts at surgical treatment of carcinoma of the esophagus have been uniformly unsuccessful is not in accord with the experience of thoracic surgeons of the last few years. The authors deny any established causative relationship between gastric ulcer and cancer; a thesis that appears to have strong pathologic support. The authors believe that chronic cystic disease is in some of its manifestations a precancerous lesion and advocate mastectomy with more assurance than more conservative surgeons would agree is justifiable.

This treatise on cancer should prove a handy reference manual in any practitioner's library. It is well written and profusely illustrated.

Classic Descriptions of Disease. With Bibliographical Sketches of the Author. Ed. 2. By Ralph H. Major, M.D. Cloth. Pp. 727, with 137 illustrations. Springfield, Ill., 1939, Charles C. Thomas, Publisher.

The author's capacity to garner informative data in a critical way and to assimilate it in a fascinating manner is demonstrated again throughout this interesting volume. The original descriptions of disease entities, which have since become generally familiar, have been made available to a wide audience in this monograph. In addition, the short biographical sketches are very well done and in them a variety of most interesting stories are brought to light: of how Jenner was refused permission by the Royal Society to communicate his observations on smallpox inoculations, with this admonition that "he ought not to risk his reputation by presenting to the learned body anything which appeared so much at variance with established knowledge, and withal so incredible"; of how Cruveilhier was filled with such a distaste for medicine upon witnessing autopsies that he fled from the medical school and entered a Catholic seminary and how his domineering father compelled his re-entry into medicine; and a number of other fascinating stories from the lives of those who have contributed richly to medicine.

As one reads this volume, one cannot help but wonder how a number of diseases, such as those described by Addison, Bright, and Raynaud and others, came to have the names of the authors attached and how in equally as important contributions in other instances this baptism of the disease or discovery does not follow.

Under the caption of diseases of the blood, wherein the writer lists the contributions of Combe, Addison, and Minot to pernicious anemia, the reviewer was distressed to note the omission of Whipple's name, without whose work the discovery of Minot might well not yet have been. Similarly in the chapter on the

instances a herniation of the intervertebral disk low in the lumbar spine was accompanied by another herniation, a complete block from a fracture of the vertebra or a tumor in the thoracic spine or in another portion of the lumbar spine. The importance of complete study of the spine after injection of iodized oil was brought out. **The Use of Thorium Dioxide Sol in Myelography** was presented by **B. H. Nichols**, Cleveland, Ohio. In a series of cases no serious ill effects were observed when the contrast medium was removed from the spinal canal by forced spinal fluid drainage. The colloidal thorium dioxide has advantages over the more viscous oily preparations in that it is more miscible with spinal fluid and can be drawn off readily by forced drainage. **L. H. Garland** and **E. J. Morrissey**, San Francisco, Calif., presented a study of **Intracranial Collections of Opaque Oils Following Lumbar Myelography.** They found large collections of iodized oil in the cranial cavity in two-thirds of 35 cases in which myelography had been done a number of years previously. In none of these cases could any evidence be obtained to indicate any harmful effects of the iodized oil.

Wendell Scott, St. Louis, Mo., emphasized the importance of the oblique position in making roentgen examinations of the spine. In this manner he was able to demonstrate fractures of the articular processes and dislocations of the apophyseal joints which had been previously overlooked.

A Symposium on Nuclear Physics in the Service of Medicine arranged by **Robert R. Newell**, San Francisco, Calif., and participated in by **M. A. Tuve**, Washington, D. C.; **William F. Bale**, Rochester, N. Y.; **John H. Lawrence**, Berkeley, Calif.; and **Robert S. Stone**, San Francisco, Calif., concerned itself with the theoretical and practical considerations of the utilization of artificially radioactive elements, both for investigation of biological reactions and for the treatment of disease. Certain radioactive metals are extremely effective, even when taken internally in the treatment of leukemia. Stone and Lawrence described the skin and mucosal reactions of patients exposed to fast neutrons, produced by the cyclotron, and the response of tumors to this type of irradiation. While still experimental, there appear to be good possibilities in this form of therapy.



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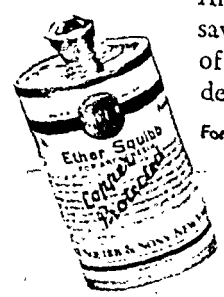
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infectious diseases, one misses the names of men like Koch, V. Behring, Wassermann, and others. The author's apology for such omission in the preface to the first edition scarcely justifies his decision. After all, in a monograph of this sort one should justifiably expect to find something of the most significant contributions to medicine. There is no word of Pasteur, nor of Lister, nor of Koch, nor of Roentgen. It is obviously a large and important labor to resurrect these fascinating classic descriptions of earlier periods, yet the omission of the most significant of classic contributions to medicine of all time is somewhat startling, if not poor emphasis, in so unique a monograph.

Failure of the Circulation. Ed. 2. By Tinsley R. Harrison, M.D. Cloth. Pp. 502, with 61 illustrations and 22 tables. Baltimore, 1939, Williams and Wilkins Company. $4.50.

The subject of the failure of the circulation the author has considered from two standpoints: (1) forward failure, and (2) backward failure, the latter being synonymous with congestive heart failure. The latter major division, to which the book is largely given over, is concerned largely with the mechanism and causes of dyspnea and embodies the well-known experiments of the author concerning the influence of reflexes in the stimulation of respiration. The work of Landis on edema formation and the effects of edema, in turn, upon the circulation are well reviewed. The forward failure of the circulation includes an intelligent discussion on surgical shock, reviewing, in part, the work of Blalock and his colleagues.

This monograph can be recommended enthusiastically to all who are interested in the mechanism and the physiology of the circulation. For internists, it presents the added feature of discussing the therapy of backward failure of the circulation in an unusually enlightened manner.

Maternal Care and Some Complications. Edited by F. L. Adair, M.D. Cloth. Chicago, 1939, University of Chicago Press. $1.50.

"The purpose of this book is to set forth in simple and concise form some of the basic principles of maternal care and of the management of three major complications." These latter are the pregnancy toxemias, obstetric hemorrhages, and puerperal infection. The book is prepared by eight of the senior obstetricians of this country and has been approved by the American Committee on Maternal Welfare. It is presumably prepared for the general practitioner who lacks time or inclination to consult more detailed sources and for nurses who work in the public health field of obstetrics. It is divided into two portions. The first makes up one-half of the book and is a detailed description of the practical aspects of ante-partum, intrapartum, and post-partum care. The second half is devoted to the three complications listed above.

The first half will serve as a useful guide and should stimulate careful observation and attention to detail. The second half suffers from a necessary brevity. In many features it appears to represent a compromise between the differing views of a number of the authors and there are numerous statements which will not find general acceptance. These are, however, details and the book should be of value in the hands of those for whom it is intended.

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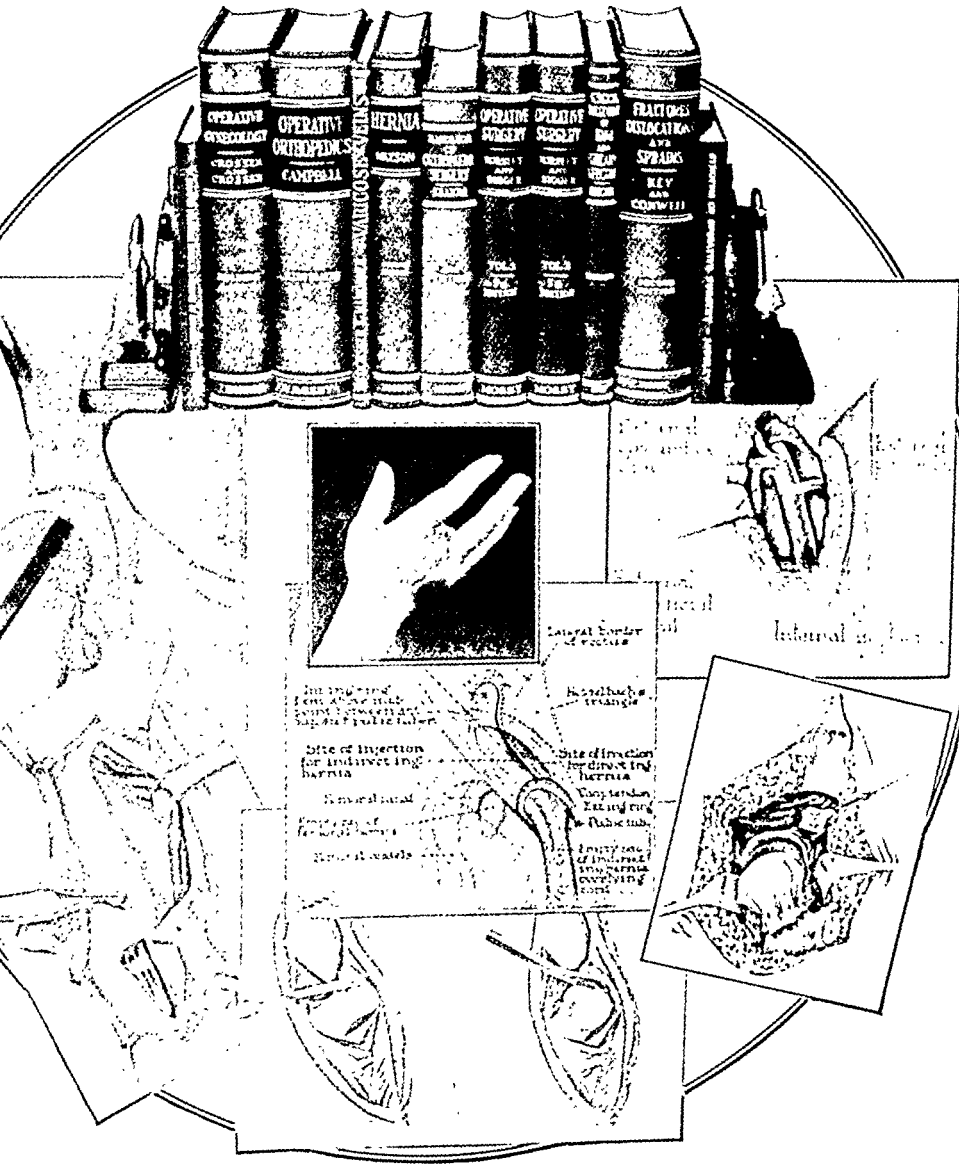
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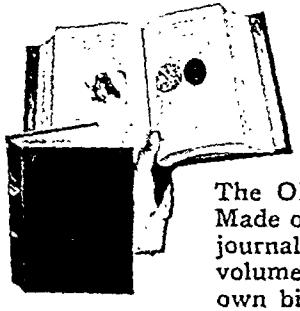
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Published by THE C. V. MOSBY COMPANY, 3523 Pine Blvd., St. Louis, U.S.A.

Great Britain Agents: Henry Kimpton, Ltd., 263 High Holborn, London, W.C.1

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Manuscripts submitted for publication may be sent to Dr. Alton Ochsner, 1430 Tulane Avenue, New Orleans, Louisiana, or to Dr. Owen H. Wangensteen, University Hospitals, Minneapolis, Minnesota.

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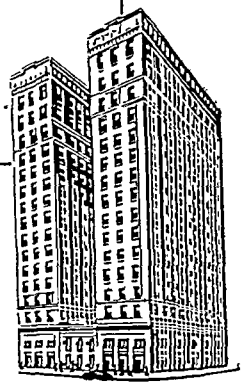
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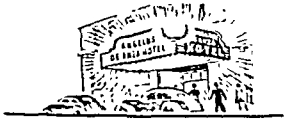
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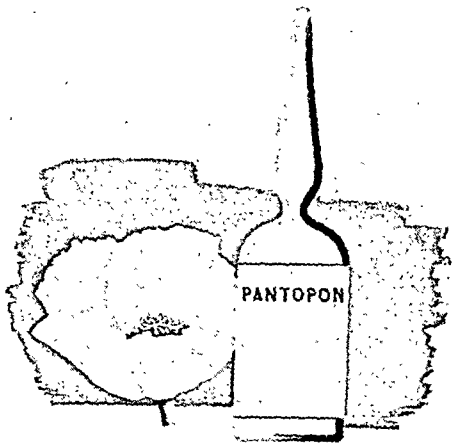
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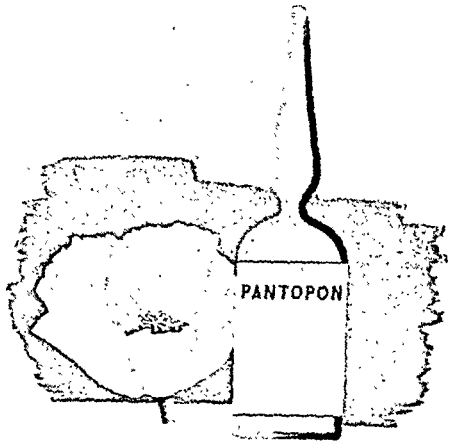
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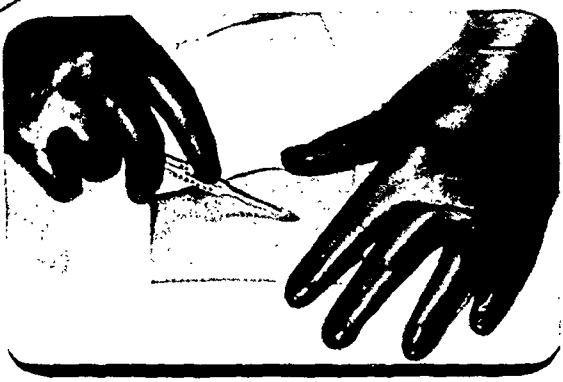
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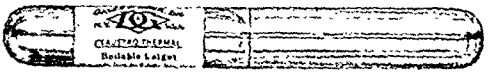
NOTE: In agreement with the new U. S. P. nomenclature, catgut products formerly known as Plain, 10-day, 20-day, and 40-day, are now designated as

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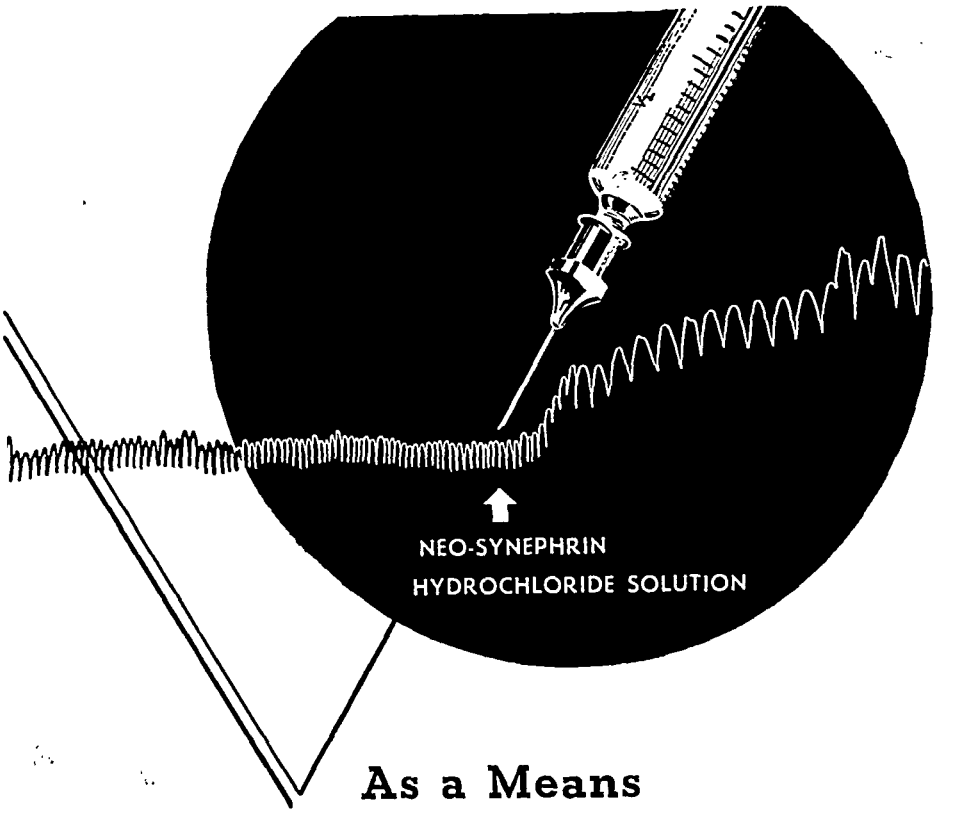
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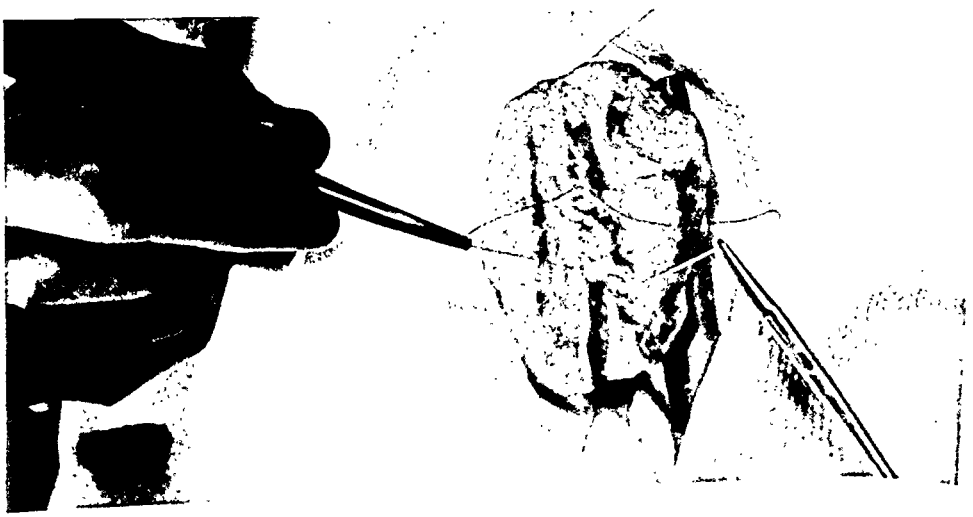
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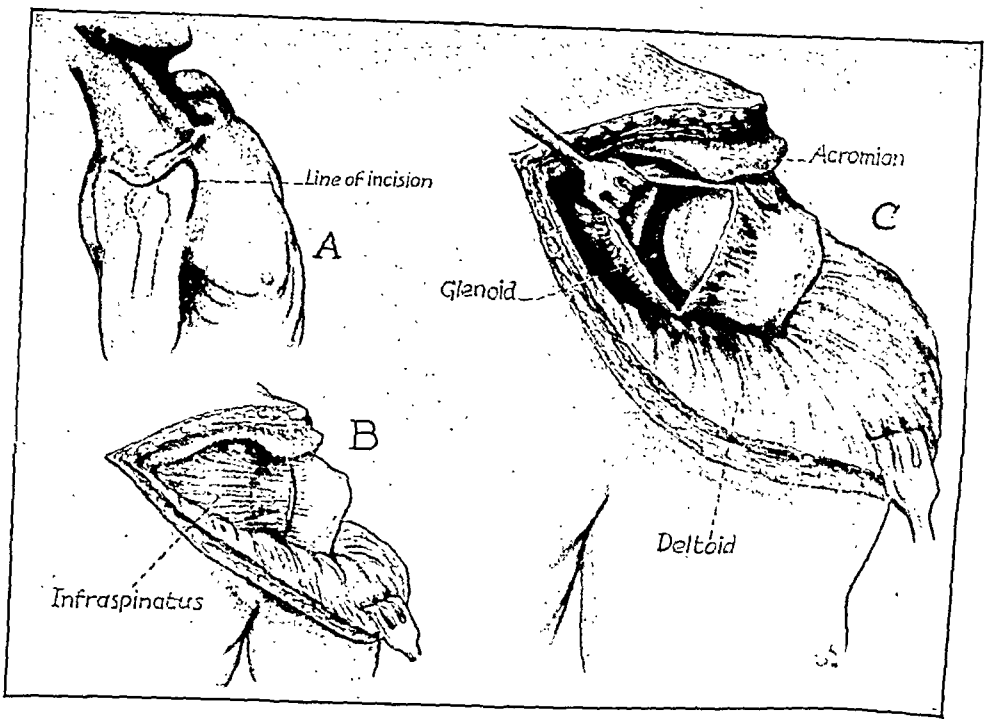
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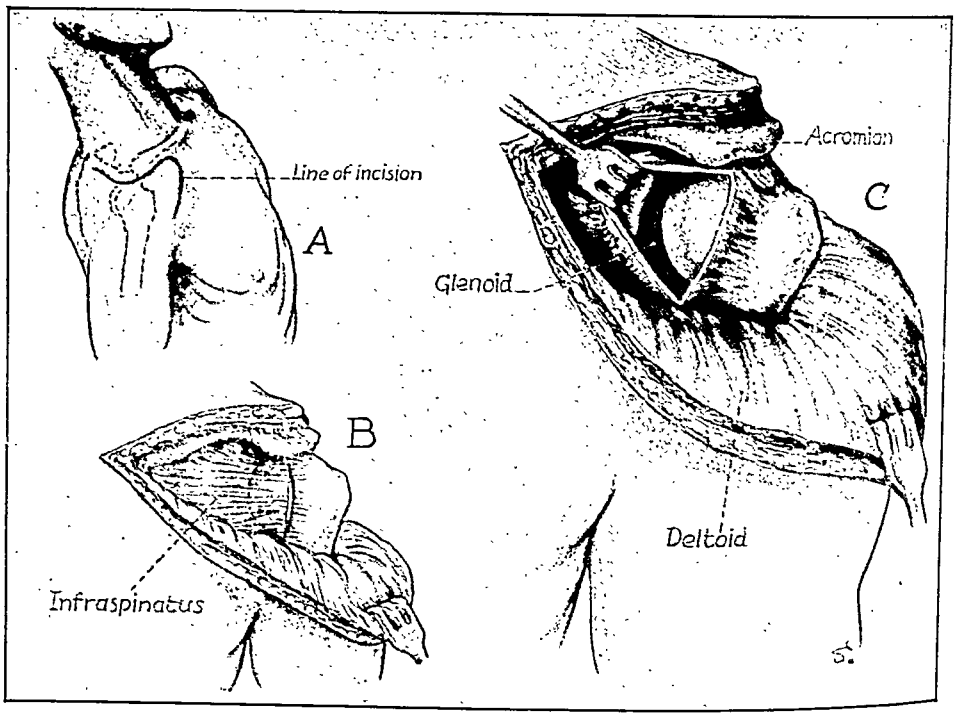
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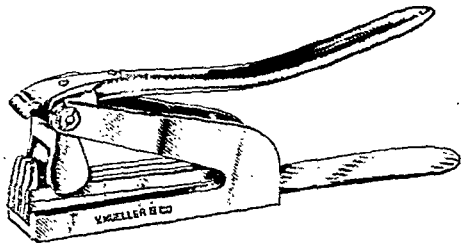
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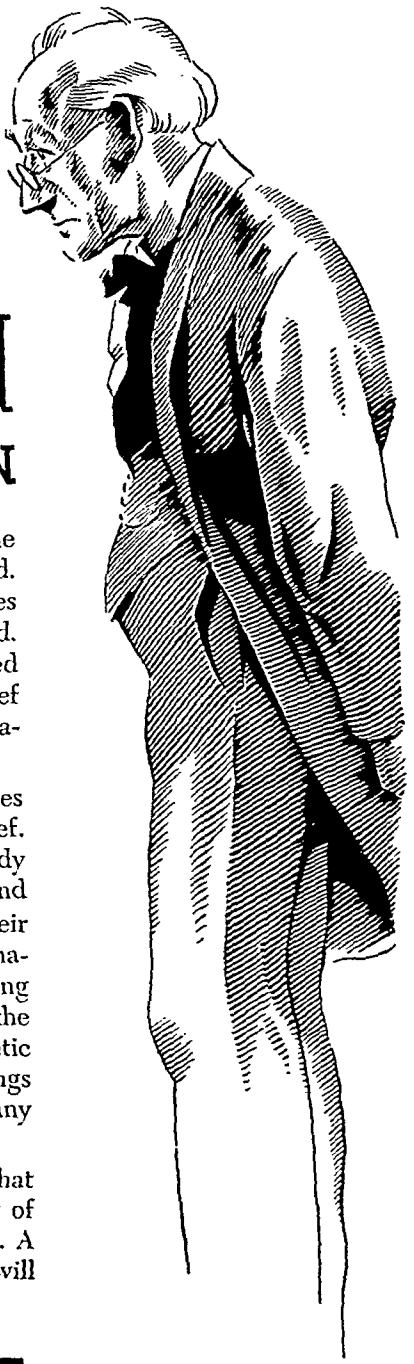
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R. H. SMITHWICK, M.D., BOSTON, MASS.

(From the Medical and Surgical Services of the Massachusetts General Hospital)

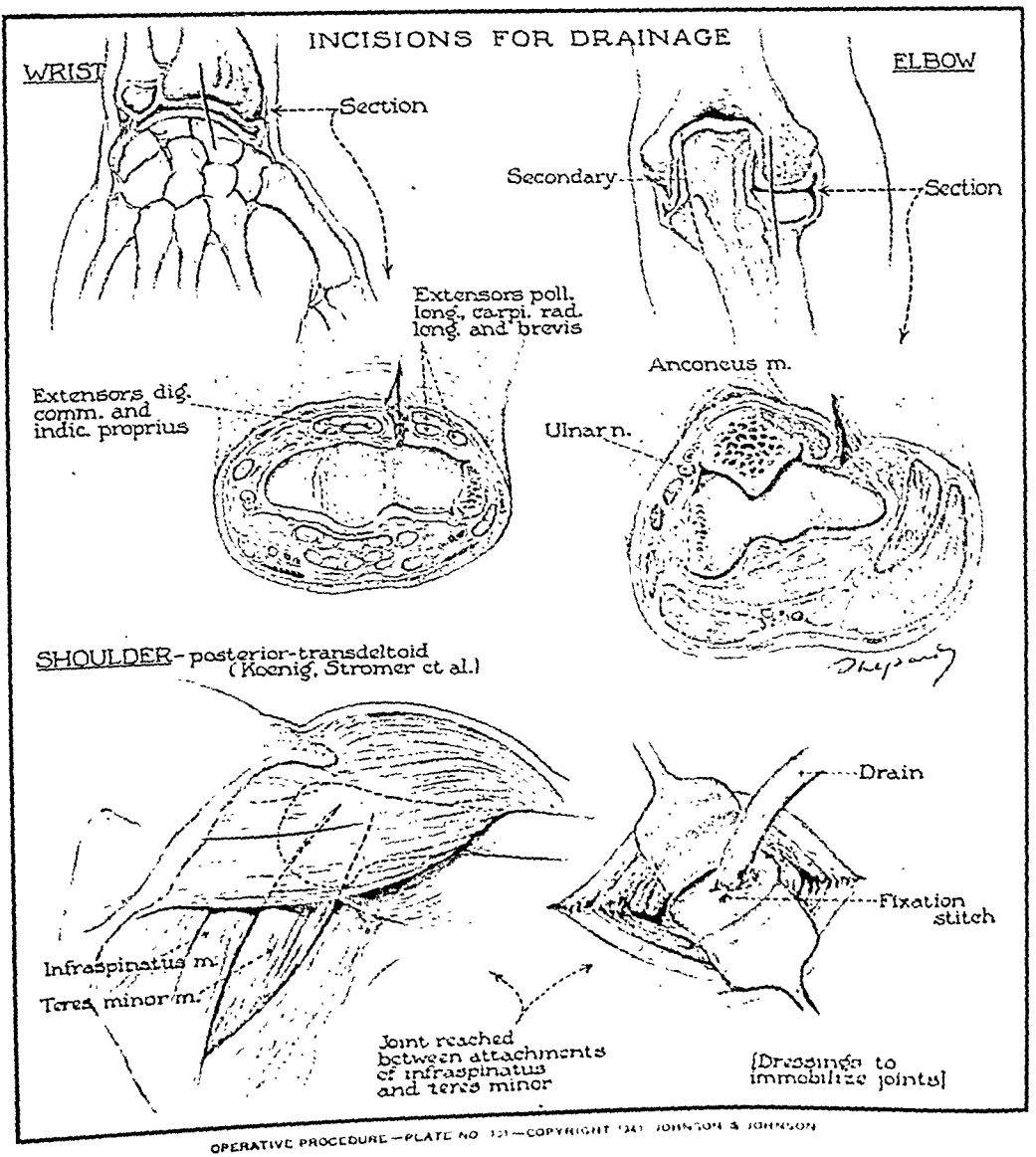
A NUMBER of methods of interrupting the splanchnic nerves in the hope of relieving hypertension have been reported in the past five or six years. Four different approaches have been suggested: intraspinal anterior root section, supradiaphragmatic splanchnic resection, subdiaphragmatic splanchnic resection, and celiac ganglionectomy.[1-6]

Our experience with these operations in approximately 150 cases of hypertension, coupled with our experience in the treatment of peripheral vascular disease by sympathectomy in several hundred cases, leads us to feel that sympathectomy yields its best results when the operation is (a) adequately complete, (b) preganglionic in type, and (c) extensive enough to guard against future regeneration of interrupted pathways.

An operation for hypertension, in our opinion, should fulfill these qualifications as far as possible, and in addition should include careful exploration of the kidneys, the adrenal glands, and the paravertebral regions. It is desirable to obtain all possible information regarding renal pathology in this disease. It is also well to exclude adrenal tumors and paragangliomas from the picture. Moreover, an operation should subject a patient to the least risk possible and should have no serious untoward effects.

In judging the results of sympathectomy for peripheral vascular disease, many objective tests are available which enable one to determine the completeness of a given operation. In the case of hypertension it is different. Symptomatic relief, changes in eyegrounds, renal function, and cardiac function are not very accurate guides as to the completeness of the interruption of splanchnic nerves. The change which

Received for publication, December 6, 1939.



OPERATIVE PROCEDURE—PLATE NO 131—COPYRIGHT 1940 JOHNSON & JOHNSON

Arthrotomy Incision (No. 1)

The Ethicon Suture series on Operative Procedure starts its tenth year with this issue. Johnson & Johnson has received many splendid comments on this series from surgeons, and hopes that in 1940 the drawings will again be found interesting and useful. "Operative Procedure," Seventh Edition, just published, contains all drawings to date. Your request to the Ligature Division will bring a complimentary copy

SUTURE MAKERS Johnson & Johnson NEW BRUNSWICK, N. J. CHICAGO, ILL.

pressure levels would result. These experiences led us to believe that there were many anatomical variations from patient to patient. The same portion of the splanchnic nerve supply was apparently not equally significant in each case. It seemed probable, however, that an operation could be done which would cover the various anatomical variations.

Our impression of the anatomical pathways to the splanchnic bed is shown in Fig. 1. It was found that adequate exposure of this entire region could be obtained by resecting the twelfth rib, through a hockey-stick incision. The upper portion is vertical, about two inches lateral to the midline, running up over the inner end of the eleventh rib. The

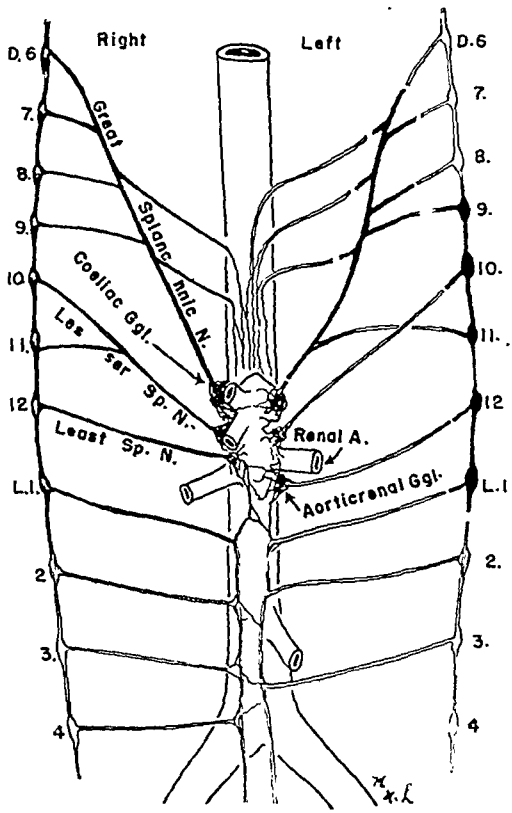


Fig. 1.—A diagrammatic sketch of the nerve supply to the splanchnic bed. On the left side the area to be removed on both sides is blacked out. This is the minimal procedure which we have found to be followed consistently by an immediate postural change in blood pressure.

lower portion curves laterally, one-half inch below and parallel to the twelfth rib. The sheath of the sacrospinalis muscle is opened vertically to below the twelfth rib, and dissection is then carried laterally following the skin incision through the deeper structures below and beyond the tip of the rib. The twelfth rib is removed from the transverse process to the lateral border of the sacrospinalis sheath. The twelfth intercostal artery, vein, and nerve are resected over a similar area. The diaphragm is divided from its lateral border to the spine,

is produced in blood pressure levels would appear to be the only reliable method of judging the completeness of the operation.

It has been our impression that complete or nearly complete splanchnic resection in man should result in a characteristic change in blood pressure in every patient with hypertension. We know that the splanchnic bed is man's mechanism for maintaining his blood pressure level relatively constant in the lying, the sitting, and the standing positions. If the splanchnic bed is well denervated, the blood pressure level should fall as the patient changes from the lying to the sitting and standing positions. Such a change has followed splanchnic resection by laminectomy and anterior root section, although this operation, in addition to interrupting sympathetic motor pathways, also divides somatic motor pathways. The latter results in extensive muscular paralysis.

Unless a postural change in blood pressure follows splanchnic resection, one cannot be certain that the maximum change in blood pressure level in the various positions has been produced. If the splanchnic bed is thoroughly denervated in man, one can perhaps also feel reasonably certain that the kidneys and the adrenal glands have been denervated as well.

Because the various operations which we had employed did not consistently produce significant postural changes or produce comparable blood pressure changes in similar cases in the horizontal position, we have been varying these procedures during the past two years in order to determine the minimal operation which would always cause a postural change in blood pressure and still fulfill the other qualifications which we felt were important.

Cases which had had a supradiaphragmatic splanchnic resection without any effect upon the blood pressure level were subjected to further surgery. At the original operation, the communicating rami of the tenth, eleventh, and twelfth dorsal segments were divided, removing the sympathetic trunk from above D10 to below D12, and removing as liberal a portion of the great splanchnic nerve as could be obtained through an eleventh rib exposure. This procedure was done on both sides. At a second operation, the upper three lumbar ganglia were removed by a subdiaphragmatic extraperitoneal approach, on each side, in two stages. In some instances, this resulted in a definite lowering of the blood pressure level with a marked postural change. In other instances there was no significant effect on the blood pressure level. This led us to feel that there must be a significant motor supply to the splanchnic bed coming from above either operative areas. That this was so was ascertained by proceeding with further interruption of the mid- and upper thoracic sympathetic chains in several cases with total sympathectomy (removal of the sympathetic trunk from above [illegible] below L3 on both sides) in one case. It was determined that, if the splanchnic bed was thoroughly denervated, a postural change in blood

TABLE II

GROUP B

NO. CASES	STAGE OF DISEASE	POSTURAL CHANGE IN BLOOD PRESSURE
1	Group II	Moderate
2	Group II	Marked
3	Group II	Moderate
4	Group II	Moderate
5	Group II	Marked
6	Group II	Marked
7	Group II	Marked
8	Group II	Marked
9	Group II	Marked
10	Group III	Marked
11	Group III	Marked
12	Group III	Moderate
13	Group IV	Marked
14	Group IV	Moderate
15	Group IV	Marked
16	Group IV	Moderate
17	Group IV	Moderate

Operation—Bilateral excision of virtually the entire great splanchnic nerve from its insertion in the celiac plexus upwards to the midthoracic level with division of all aortic branches above the diaphragm. Interruption of the communicating rami of *D9, D10, D11, D12,* and *L1* with excision of the sympathetic trunk over this area.

In Group C cases (Table III) the same operation was done as in Group B cases, only in addition the communicating rami of L2 were divided and the ganglion itself removed on one or both sides. The immediate effect of the operation, as judged by postural change in blood pressure level, varied in the three groups. In the six cases of Group A (Table I) three showed no significant postural change, while two had a slight and one a moderate fall in systolic and diastolic levels accompanied by a fall in pulse pressure and a rise in pulse rate in the sitting and standing positions as contrasted with the lying position.

TABLE III

GROUP C

NO. CASES	STAGE OF DISEASE	POSTURAL CHANGE IN BLOOD PRESSURE
1	Group II	Profound
2	Group III	Profound
3	Group IV	Profound

Operation—Bilateral excision of virtually the entire great splanchnic nerve from its insertion in the celiac plexus to the middorsal level with division of the aortic branches. Interruption of the communicating rami of D9, D10, D11, D12, L1 with the excision of the sympathetic trunk over this area. In addition, the rami of the second lumbar ganglion were interrupted and the ganglion removed on one or both sides.

In Group B (Table II) all seventeen cases had a characteristic and definite immediate postural change. This change occurred very rapidly, in about thirty seconds after shifting position. One week after the operation was completed, the standing blood pressures were very low. As a rule, both systolic and diastolic levels were below 100 with a pulse pressure of less than 20 mm. The patient was unable to stand for more than a minute in most instances without fainting. In the course of another week, the tone of the splanchnic bed returned to some extent,

one inch below and parallel to the pleural reflection. The pleura is then separated from the thoracic cage up to the middorsal region. The kidney then is readily exposed and inspected. An excellent view is obtained of the entire organ including its pedicle. The adrenal gland is readily seen and explored. The sympathetic trunk and paravertebral region are exposed from D9 to below L2. The great splanchnic nerve can be seen from its insertion in the celiac plexus upwards for virtually its entire extent, with its important branches running to the aorta above the diaphragm. The exploration having been completed, the desired portion of the splanchnic supply is then removed, the diaphragm resutured, and the wound closed in layers with silk technique. Intratracheal anesthesia is used. The operation is done in two stages between one and two weeks apart. Since September, 1938, this operation has been used in a series of twenty-six cases. There has been no operative mortality. There have been no serious complications.

These cases may be divided into three groups. In all, virtually the entire great splanchnic nerve was removed from its insertion in the celiac ganglion upward to the midthoracic level. The ganglion was not disturbed, but care was taken to divide all branches running from the great splanchnic nerve to the aorta above the diaphragm. Different portions of the sympathetic trunk itself were removed in each group, in order to complete the denervation of the splanchnic bed and to ascertain the minimal procedure which would consistently produce the desired effect. In Group A cases (Table I) the communicating rami of D9, D10, D11, and D12 were sectioned, and the sympathetic trunk was removed over this area.

TABLE I*

GROUP A

NO. CASES	STAGE OF DISEASE	POSTURAL CHANGE IN BLOOD PRESSURE
1	Group I	Moderate
2	Group II	Slight
3	Group II	Insignificant
4	Group II	Insignificant
5	Group IV	Moderate
6	Group IV	Insignificant

*Operation—Bilateral excision of virtually the entire great splanchnic nerve from its insertion in the celiac plexus upwards to the middorsal level with division of all aortic branches above the diaphragm. Interruption of the sympathetic trunk over this area. In all tables the cases are divided into four groups according to the stage of the disease, D9, D10, D11, D12, with excision of the sympathetic trunk and communicating rami of this division is based largely upon eyeground changes. In all cases I stage of the disease, evidence of change in the retinal arterioles, chiefly vasoconstriction, with no change in the heart or kidneys. Group II cases have more marked retinal change with caliber variation in the arterioles, nicking at the venous crossings in addition to vasoconstriction. There is no hemorrhage or exudate in cases in Groups I and II. In Group II there may be slight enlargement of the heart and minimal evidence of altered renal function. Group III cases show hemorrhage and exudate in the eyegrounds and enlarged hearts, usually with coronary changes; some have had a cerebral accident, and usually show some evidence of impaired renal function. Group IV cases are those in the malignant phase of the disease, who, in addition to those changes which are usually present in Group III, also show edema and elevation of the disk.

In Group B cases (Table II) the communicating rami of D9, D10, D11, D12, and L1 were divided, removing the sympathetic trunk over this area.

TABLE II

GROUP B

NO. CASES	STAGE OF DISEASE	POSTURAL CHANGE IN BLOOD PRESSURE
1	Group II	Moderate
2	Group II	Marked
3	Group II	Moderate
4	Group II	Moderate
5	Group II	Marked
6	Group II	Marked
7	Group II	Marked
8	Group II	Marked
9	Group II	Marked
10	Group III	Marked
11	Group III	Marked
12	Group III	Moderate
13	Group IV	Marked
14	Group IV	Moderate
15	Group IV	Marked
16	Group IV	Moderate
17	Group IV	Moderate

Operation—Bilateral excision of virtually the entire great splanchnic nerve from its insertion in the celiac plexus upwards to the midthoracic level with division of all aortic branches above the diaphragm. Interruption of the communicating rami of D9, D10, D11, D12, and L1 with excision of the sympathetic trunk over this area.

In Group C cases (Table III) the same operation was done as in Group B cases, only in addition the communicating rami of L2 were divided and the ganglion itself removed on one or both sides. The immediate effect of the operation, as judged by postural change in blood pressure level, varied in the three groups. In the six cases of Group A (Table I) three showed no significant postural change, while two had a slight and one a moderate fall in systolic and diastolic levels accompanied by a fall in pulse pressure and a rise in pulse rate in the sitting and standing positions as contrasted with the lying position.

TABLE III

GROUP C

NO. CASES	STAGE OF DISEASE	POSTURAL CHANGE IN BLOOD PRESSURE
1	Group II	Profound
2	Group III	Profound
3	Group IV	Profound

Operation—Bilateral excision of virtually the entire great splanchnic nerve from its insertion in the celiac plexus to the middorsal level with division of the aortic branches. Interruption of the communicating rami of D9, D10, D11, D12, L1 with the excision of the sympathetic trunk over this area. In addition, the rami of the second lumbar ganglion were interrupted and the ganglion removed on one or both sides.

In Group B (Table II) all seventeen cases had a characteristic and definite immediate postural change. This change occurred very rapidly, in about thirty seconds after shifting position. One week after the operation was completed, the standing blood pressures were very low. As a rule, both systolic and diastolic levels were below 100 with a pulse pressure of less than 20 mm. The patient was unable to stand for more than a minute in most instances without fainting. In the course of another week, the tone of the splanchnic bed returned to some extent,

probably due to intrinsic and humoral mechanisms, so that he could begin to walk (Figure 2). By the end of three weeks, he usually was able to leave the hospital. As months passed, the postural change was less abrupt, but it usually was still present to some degree. The pulse

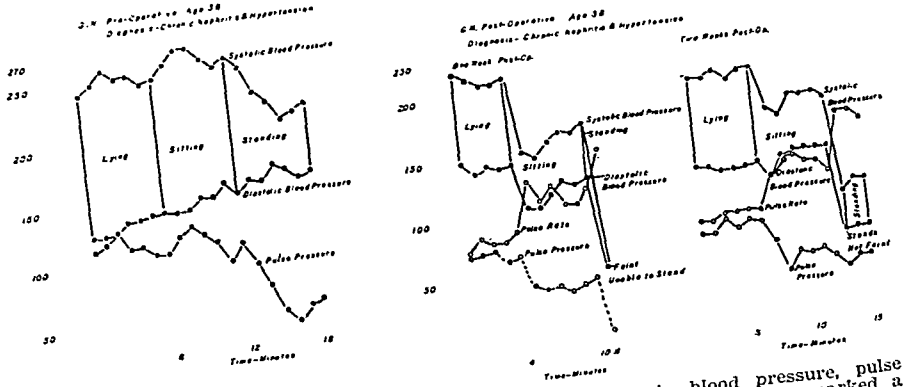


Fig. 2.—This chart shows the typical abrupt change in blood pressure, pulse pressure, and pulse rate one week after operation. The change is less marked a week later, when the standing blood pressure level is 100/60. This case happens to be a severe chronic nephritic with secondary hypertension. The character of the blood pressure change is the same as that seen after operation in primary hypertensives.

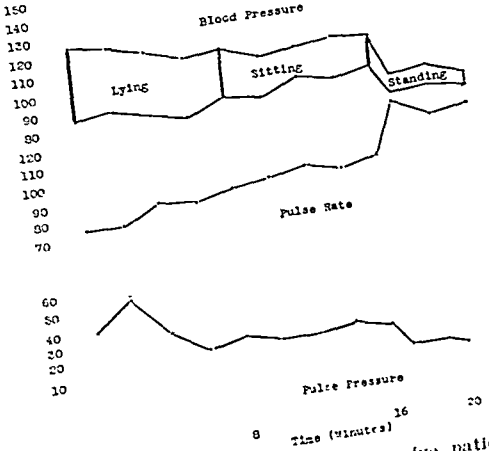


Fig. 3.—Blood pressure levels in an essential hypertensive patient (Group II) five months after operation.

pressure remained lower, and the pulse rate tended to rise as the patient shifted from the lying to the sitting and standing positions (Figs. 3, 4, 5).

In the three cases of Group C (Table III) the postural change was profound. In these the second lumbar ganglion had been removed on one or both sides in addition to what was resected in Group A and

Group B cases. It appeared to take a longer time for these patients to acquire an adequate standing blood pressure level.

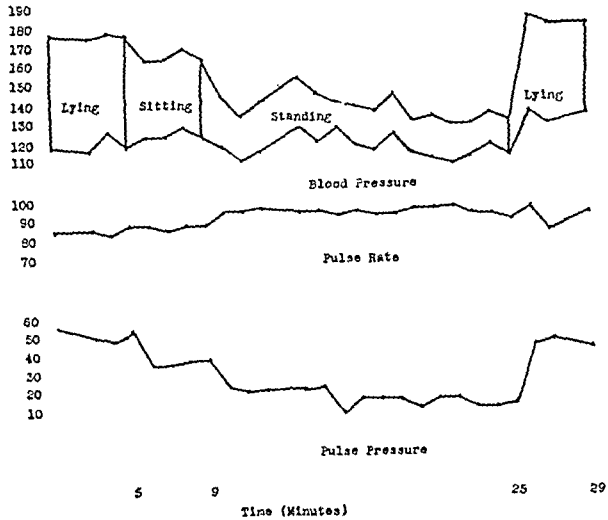


Fig. 1.—Blood pressure levels in a patient with malignant hypertension (Group IV) five months after operation.

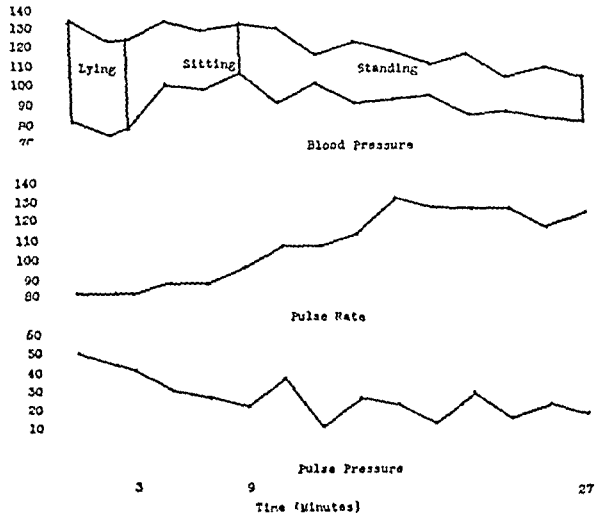


Fig. 5.—Blood pressure levels in a malignant hypertensive patient (Group IV) ten months after operation.

From these experiences, it would seem that, if the splanchnic bed is thoroughly denervated, an immediate postural change in blood pressure will result in every case. Under these circumstances the blood pressure level in all positions has been lower than before operation. The pulse pressure has been lowered in all instances. If splanchnic denervation is less complete, and no significant postural change is noted, it has been our experience that there often is no significant change

in the blood pressure level in any position, particularly in cases in the more advanced stages of the disease. Apparently, a few uninterrupted fibers are capable of supplying enough tone to the splanchnic area so that there may be no significant change in blood pressure after operation.

Removal of virtually the entire great splanchnic nerve with division of all of its aortic branches coupled with interruption of the communicating rami of D9, D10, D11, D12, and L1, together with excision of the sympathetic trunk over this area, is the minimal procedure which we have found consistently to produce a blood pressure change which is characteristic of a thorough interruption of the nerve supply to the splanchnic bed.

Whether removal of the outflow from L2 as well is necessary or desirable has not been determined as yet.

It will take several years to ascertain the value of this procedure in the treatment of hypertension in the various stages of the disease.

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THE SILK TECHNIQUE

Experimental Observations

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IT HAS been demonstrated repeatedly that a wound sutured with fine silk is less apt to suppurate than is a corresponding wound sutured with catgut.[1-3] This important consideration, coupled with the obvious advantages of silk as regards economy and reliability of sterilization, has aroused an increasing interest in "silk surgery." With the more widespread adoption of the silk technique, a number of questions have been raised regarding the proper sizes and types of silk which should be employed and regarding the technique of preparing and using the silk. It has been the purpose of the present study to attempt to answer some of these questions.

Economy of Silk.—The surgeon who has been accustomed to using catgut is likely to employ a similar technique when using silk. Thus, the silk is frequently wound on spools or small cards for sterilization and is handed to the surgeon in fairly long strands from which are made as many ties or sutures as possible in order to avoid waste. Silk is so inexpensive, however, that such efforts toward economy are entirely unnecessary, affecting as they will a saving of only a few pennies in even the most extensive operation (Table I). When the silk

Table I

Approximate Cost of Suture Material Per Operation, Showing the Great Economy in Using Silk; the Prepared Silks, Though Substantially Cheaper Than Catgut, Are More Than Twenty Times as Expensive as Untreated Silk

Amount Used	Belden Twist No. A	Champion Twist No. 3	Champion Braid No. 0	Champion "Serum-proof" Braid No. 0	Deknatel "Mois-ture-proof" Braid No. C	Chromicized Catgut No. 000
50 12-inch strands	$0.023	$0.026	$0.031	$0.48	$0.56	$1.90
100 12-inch strands	0.047	0.053	0.062	0.95	1.12	3.80
50 18-inch strands	0.037	0.04	0.046	0.70	0.85	2.87
100 18-inch strands	0.075	0.08	0.093	1.40	1.70	5.75

is prepared and used as above, the strands tend to be kinky and the technique is cumbersome. It is far more convenient to use a separate

Received for publication, June 22, 1939.

strand of a liberal length for each tie or stitch. If the silk is wound on a board about nine inches in length (eighteen-inch strands are handled more easily than shorter lengths), the hank of silk may be cut across at the operating table and the individual strand handed to the surgeon as it is needed (Fig. 1).

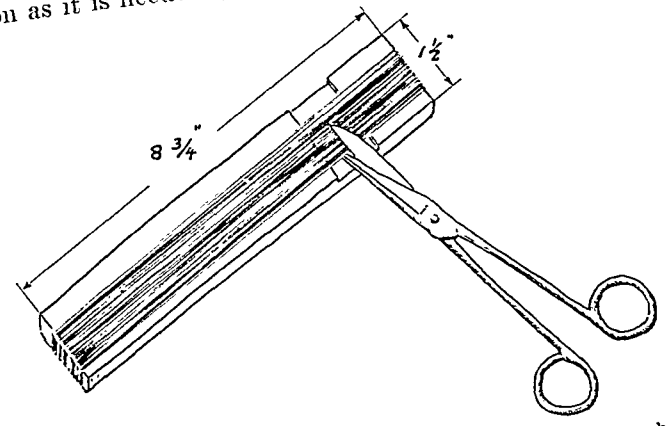


Fig. 1.—A convenient method for handling silk. Thread is wound on board before sterilization. If lubrication is desired, a small amount of vaseline, liquid petrolatum, or wax is applied to board before winding silk on it. Board then may be either boiled or autoclaved. Ends of board are smoothed to prevent fraying of silk.

Effect of Sterilization.—It has generally been held that sterilization, whether by boiling or autoclaving, weakens the silk and it has therefore been considered undesirable to prolong the period of sterilization or to use silk which has been sterilized more than once. Our observations, which accord with previous studies,[4-6] show that neither method of sterilization causes an appreciable loss of tensile strength even though the period of heating be prolonged or repeatedly applied. (Tables II, III, and IV.) Repeated boiling does increase the friability of silk, but this increase is too slight to be of clinical importance (Table V).

TABLE II

EFFECT OF REPEATED AUTOCLAVING ON THE TENSILE STRENGTH OF SILK; TESTS MADE ON DRY SILK; EACH READING IS THE AVERAGE OF TWO DETERMINATIONS

DATE	TREATMENT	CHAMPION BRAID NO. 1		CHAMPION TWIST NO. 3	
		PLAIN	"SERUM-PROOF"	PLAIN	"SERUM-PROOF"
1/ 4/38	Controls	4.25 lb.	3.58 lb.	3.6 lb.	3.4 lb.
	Autoclaved 10 min.	4.3 lb.	3.6 lb.	3.4 lb.	3.6 lb.
1/10/38	Autoclaved 10 min.				
1/11/38	Autoclaved 10 min.	4.18 lb.	3.5 lb.	3.37 lb.	3.56 lb.
1/16/38	Autoclaved 10 min.	4.31 lb.	3.75 lb.	3.43 lb.	3.43 lb.
1/17/38	Autoclaved 10 min.	4.18 lb.	3.75 lb.	3.43 lb.	3.56 lb.
1/18/38	Autoclaved 10 min.				
1/20/38	Autoclaved 10 min.	4.25 lb.	3.68 lb.	3.5 lb.	3.5 lb.

TABLE III

EFFECT OF REPEATED BOILING ON THE TENSILE STRENGTH OF SILK; TESTS MADE ON DRY SILK EXCEPT WHERE OTHERWISE INDICATED; EACH READING IS THE AVERAGE OF THREE DETERMINATIONS

DATE	TREATMENT	CHAMPION BRAID NO. 1		CHAMPION TWIST NO. 3	
		PLAIN	"SERUM-PROOF"	PLAIN	"SERUM-PROOF"
12/24/37	Controls	4.25 lb.	3.58 lb.	3.62 lb.	3.37 lb.
	Boiled 10 min.	3.31 lb. (wet)	2.75 lb. (wet)	2.56 lb. (wet)	2.68 lb. (wet)
		4.0 lb.	3.5 lb.	3.56 lb.	3.33 lb.
12/29/37	Boiled 10 min.	3.9 lb.	3.41 lb.	3.37 lb.	3.08 lb.
12/30/37	Boiled 10 min.	4.1 lb.	3.5 lb.	3.56 lb.	3.31 lb.
		3.0 lb. (wet)	2.75 lb. (wet)	2.62 lb. (wet)	2.5 lb. (wet)
1/ 4/38	Boiled 10 min.	4.25 lb.	3.62 lb.	3.56 lb.	3.37 lb.
1/ 5/38	Boiled 20 min.	4.12 lb.	3.43 lb.	3.5 lb.	3.25 lb.
1/ 7/38	Boiled 10 min.	3.93 lb.	3.18 lb.	3.25 lb.	3.12 lb.
1/ 8/38	Boiled 10 min.	4.31 lb.	3.75 lb.	3.56 lb.	3.31 lb.
		3.25 lb. (wet)	2.87 lb. (wet)	2.5 lb. (wet)	2.62 lb. (wet)

TABLE IV

EFFECT OF BOILING PERIOD ON THE TENSILE STRENGTH OF SILK; TESTS MADE ON DRY SILK

PERIOD OF BOILING	CHAMPION BRAID NO. 0	
	PLAIN	"SERUM-PROOF"
Control	2.3 lb.	3.0 lb.
5 min.	2.2 lb.	2.9 lb.
10 min.	2.0 lb.	2.8 lb.
15 min.	1.9 lb.	2.7 lb.
20 min.	2.0 lb.	2.7 lb.
30 min.	2.0 lb.	2.7 lb.

TABLE V

EFFECT OF REPEATED BOILING ON THE FRIABILITY OF SILK; TESTS MADE ON WET SUTURE TIED IN A SQUARE KNOT AROUND A CORK; SILK BOILED FOR 10 MIN. AT EACH PERIOD

NUMBER OF TIMES BOILED	NO. 3 TWIST PLAIN	NO. 3 TWIST "SERUM-PROOF"	NO. 0 BRAID PLAIN	NO. 0 BRAID "SERUM-PROOF"
(Controls)	1.9 lb.	1.6 lb.	1.6 lb.	2.0 lb.
1	1.5 lb.	1.6 lb.	1.5 lb.	1.9 lb.
2	1.6 lb.	1.6 lb.	1.5 lb.	1.8 lb.
3	1.7 lb.	1.5 lb.	1.3 lb.	1.6 lb.
4			1.3 lb.	1.7 lb.

In contrast to the resistance of silk to heat, we find that simply wetting the silk causes a prompt loss in tensile strength of about 25 per cent. This weakening effect is not caused by deteriorization because the silk regains its original strength upon drying and because it does not show a progressive loss in strength on soaking (Table VI).

The above observations hold true for braided as well as for twisted silk and for silk which has been treated with oil or wax as well as for

TABLE VI

EFFECT OF PROLONGED WETTING ON THE TENSILE STRENGTH OF SILK
(CHAMPION TWIST NO. 3)

PERIOD OF SOAKING (IN WATER)	UNTREATED	VASELINE	LIQUID PETROLATUM	WAXED	"SERUM-PROOF"
5 min.	2.3 lb.	2.9 lb.	2.7 lb.	2.2 lb.	2.4 lb.
24 hr.	2.3 lb.	2.2 lb.	2.3 lb.	2.2 lb.	2.1 lb.
7 days	2.3 lb.	2.1 lb.	2.2 lb.	2.2 lb.	2.1 lb.
14 days	2.2 lb.	2.1 lb.	2.1 lb.	2.2 lb.	2.1 lb.
21 days	2.2 lb.	2.1 lb.	2.1 lb.	2.1 lb.	2.1 lb.
28 days	2.2 lb.	2.0 lb.	2.0 lb.	2.1 lb.	2.0 lb.

untreated silk. One would think that wax or oil would protect the silk from the weakening effect of water, but such is not the case. The penetration of moisture is only delayed for a brief period by a coating of beeswax and for a slightly longer period by liquid petrolatum or vaseline (Table VII).

TABLE VII

EFFECT OF LUBRICATION AS A PROTECTION AGAINST MOISTURE
(CHAMPION TWIST NO. 3)

	TENSILE STRENGTH				
	UNTREATED	LIQUID PETROLATUM	VASELINE	WAX	"SERUM-PROOF"
Dry	3.5 lb.	3.4 lb.	3.25 lb.	3.4 lb.	3.4 lb.
Soaked 1 min.	2.5 lb.	3.1 lb.	3.0 lb.	2.6 lb.	3.31 lb.
5 min.	2.5 lb.	2.5 lb.	2.75 lb.	2.5 lb.	3.0 lb.
20 min.	2.4 lb.	2.5 lb.	2.5 lb.	2.5 lb.	2.68 lb.

Although the silk, of course, becomes moistened as it is placed in the tissues, there will be less troublesome breaking if the strands are dry when they are used. For this reason autoclaved silk will show less tendency to break than silk which has been boiled unless the latter is allowed to dry thoroughly before it is used. Oiled silk will break less easily than untreated silk because the protection against moisture, even though transitory, will allow time for the knots to be placed. Especially to be avoided, however, is the oiling of silk while it is wet because this slows up the drying process and the strands will still be weak from moisture when they are handed to the surgeon. (Table VIII.)

Lubrication of Silk.—Untreated silk has a tendency to fray and break, especially when knots are being tied under tension, and for this reason it is convenient to treat the silk with oil or wax.* This may be done at the operating table or before the silk is sterilized. The latter is preferable because excess lubrication is more easily avoided.

*The processing employed in the preparation of champion "serum-proof" silk (Gudebrod Bros.) or Deknatel's "moisture and serum-proof" silk is apparently largely an impregnation with wax. In our hands these sutures were found to show the physical characteristics of silk which has been treated with wax alone.

TABLE VIII

EFFECT OF LUBRICATION ON THE RATE OF DRYING OF WET SILK; SILK (CHAMPION NO. 3 TWIST) LUBRICATED WHILE WET AND ALLOWED TO DRY AT ROOM TEMPERATURE

	TENSILE STRENGTH		
	UNTREATED	VASELINE	WAX
Soaked 5 min.	2.75 lb.	2.68 lb.	2.5 lb.
Dried for 5 min.	3.37 lb.	2.6 lb.	2.6 lb.
Dried for 15 min.	3.4 lb.	2.75 lb.	2.9 lb.
Dried for 30 min.	3.6 lb.	2.75 lb.	
Dried for 45 min.	3.5 lb.	2.6 lb.	
Dried for 60 min.		2.7 lb.	3.4 lb.

Neither oil nor wax increases the tensile strength of the silk (Table IX). Vaseline or mineral oil makes the silk slightly less friable and prevents fraying, but the knots do not slide down smoothly. Beeswax is distinctly superior to oil in its effect on the sliding quality, but it must be appreciated that this advantage is obtained only at the expense of the stability of the knot. As will subsequently be shown, it is almost impossible to tie a reliable knot in silk which has been treated with wax alone. A combination of wax and vaseline combines the advantages of each and at the same time the sliding quality can be regulated by increasing the proportion of vaseline so that the proper type of knot will hold fairly well. It was found that approxi-

TABLE IX

EFFECT OF LUBRICATION ON THE TENSILE STRENGTH OF SILK (CHAMPION TWIST NO. 3)

	UNTREATED	LIQUID PETROLATUM	VASELINE	WAX	"SERUM-PROOF"
Dry	3.5 lb.	3.37 lb.	3.25 lb.	3.5 lb.	3.25 lb.
	3.5 lb.	3.37 lb.	3.25 lb.	3.37 lb.	3.38 lb.
	3.5 lb.	3.62 lb.	3.62 lb.	2.87 lb.	3.25 lb.
	3.3 lb.	3.62 lb.	3.63 lb.	3.13 lb.	3.11 lb.
Average	3.45 lb.	3.5 lb.	3.44 lb.	3.22 lb.	3.25 lb.
Wet (5 min.)	2.5 lb.	2.75 lb.	3.11 lb.	2.5 lb.	2.37 lb.
	2.5 lb.	3.37 lb.	3.12 lb.	2.5 lb.	2.5 lb.
	2.5 lb.	3.0 lb.	3.10 lb.	2.5 lb.	2.63 lb.
Average	2.5 lb.	3.04 lb.	3.12 lb.	2.5 lb.	2.5 lb.

mately equal parts of vaseline and beeswax melted together and allowed to harden will provide a satisfactory lubricant (Table X). An excess amount of lubricant on the silk is undesirable and it is indeed surprising how small an amount is required if it is properly applied. A convenient method is to rub a little of the mixture on both sides of the board on which the silk is to be wound. As little as 0.25 c.c. will be found sufficient for 100 turns of silk. The board is now wound, wrapped in cloth, and autoclaved.

TABLE X

EFFICIENCY OF VASELINE AND BEESWAX AS A LUBRICANT FOR SILK; THIN COATING OF LUBRICANT APPLIED TO BOARD BEFORE WINDING ON THE SILK THREAD AND AUTOCLAVING

LUBRICANT	SLIDING QUALITY	HOLDING POWER OF SQUARE KNOT	HOLDING POWER OF TRIPLE-THROW
Untreated	0	++++	++++
Vaseline 100 parts, Beeswax 1 part	+	+++	++++
Vaseline 20 parts, Beeswax 1 part	+	+++	++++
Vaseline 5 parts, Beeswax 1 part	++	++	+++
Vaseline 2 parts, Beeswax 1 part	++	++	+++
Vaseline 4 parts, Beeswax 3 parts	+++	+	+++
Vaseline 1 part, Beeswax 1 part	+++	0	+++
Vaseline 2 parts, Beeswax 3 parts	+++	0	++
"Serum-proof" Beeswax	+++	0	+
	++++	0	+

The objection might be raised to lubricating the silk before sterilization that the oil and wax might protect resistant spores. The objection does not apply to this method, however, for our tests have shown that silk contaminated with the *Bacillus subtilis* and prepared as described above was uniformly sterile after autoclaving for ten minutes at fifteen pounds pressure.*

Reliability of Knots.—An important advantage of silk over catgut is the greater reliability of the knot, and it is generally assumed that a square knot in silk will not slip. Critical observation, however, shows that this cannot be accepted without certain reservations.

A simple method for testing the holding power of a knot is to tie a strand about the blades of a hemostat and observe the tendency to slip when the blades are separated. The square knot is found to be completely reliable only when untreated silk is used. When the silk has been vaselined, the square knot slips slightly but the triple-throw knot is reliable. When the silk has been waxed or "serum-proofed," a square knot slips readily and even a triple-throw knot fails to hold. (Table XI.) This is true no matter how the triple-throw knot is formed, and indeed the knot will slip even after a fourth turn has been added. Since the strength of a knot will vary somewhat according to how

*There is a real danger that oil-covered materials, such as vaselined gauze, will not be adequately sterilized by the usual methods. This is especially true if the material is in a bulky roll. Our studies have shown that such a roll of gauze one inch in diameter contaminated with *Staphylococcus aureus, Bacillus pyocyaneus, or Bacillus subtilis* will yield a positive culture after autoclaving for ten minutes but not after twenty minutes. We have seen pyocyaneus infections develop in clean wounds packed with vaselined gauze which had been autoclaved in rolls about two inches in diameter

TABLE XI

HOLDING POWER OF KNOTS AS TESTED ON BLADES OF HEMOSTAT; CHAMPION SILK EXCEPT WHERE OTHERWISE STATED; ALL TESTS MADE ON WET SUTURE; THE SQUARE KNOT IS FOUND TO BE RELIABLE ONLY WITH UNTREATED SILK

TYPE OF KNOT	TWIST NO. 3 PLAIN	BRAID NO. 0 PLAIN	TWIST NO. 3 VASELINED	TWIST NO. 3 WAXED	TWIST NO. 3 "SERUM-PROOF"	BRAID NO. 0 "SERUM-PROOF"	(DEKNATEL) BRAID NO. D "MOISTURE-PROOF"
Granny	++	++	+	0	0	0	0
Square	++++	++++	+++	+	+	+	+
Surgeon's	++++	++++	++++	++	++	++	++
Triple-throw	++++	++++	++++	+++	+++	+++	+++

tightly it has been tied, tests were made with this factor controlled in a tensiometer and the results were found to be the same.

The reliability of knots was further tested, in a manner to simulate clinical conditions, by uniting strips of cloth and observing the tensile strength of the suture line. The ends were cut close to the knot (1 or 2 mm.) as is the accepted practice in the silk technique. With the untreated silk the sutures broke before the square knots untied and even the slip knots held fairly well. Vaselined silk held reliably with the triple-throw knot. Again it was observed that a completely reliable knot could not be tied with waxed or "serum-proofed" silk for with this material the knots always untied before the silk broke, even where the triple-throw knot was used. (Table XII.)

TABLE XII

RELIABILITY OF KNOTS DEMONSTRATED BY TENSILE STRENGTH OF A ROW OF FOUR INTERRUPTED SUTURES IN MUSLIN; FIGURES ARE THE AVERAGE OF SEVERAL DETERMINATIONS; WHERE "SERUM-PROOF" SILK WAS USED THE KNOTS BECAME UNTIED IN EVERY INSTANCE, EVEN WHEN THE TRIPLE-THROW KNOT WAS USED

SUTURE MATERIAL	SQUARE KNOT	GRANNY (FLAT)	GRANNY (NOT FLAT)	SLIP (SQUARE)	SLIP (GRANNY)	TRIPLE-THROW	SURGEON'S
No. 3 twist (plain)	12.8 lb.	12 lb.	11 lb.	11.0 lb.	10.5 lb.		
No. 0 braid (plain)	9.0 lb.						
No. 3 twist (vaselined)	8.0 lb.					14.0 lb.	
No. 3 twist ("serum-proof")	3.5 lb.	2 lb.		1.5 lb.	1.4 lb.	5.0 lb.	3.5 lb.
No. 0 braid ("serum-proof")	3.5 lb.					4.5 lb.	4.0 lb.
No. 2 braid ("serum-proof")	5.5 lb.						
No. 3 braid ("serum-proof")	4.0 lb.						
No. 5 braid ("serum-proof")	11.5 lb.						

The length of the cut ends is generally considered to be an important factor in the tensile strength of a knot and it has been suggested that, even in the case of silk, the ends should be left at least 3 mm. long.[7] This is contrary to the teaching of the Halsted school which insists that the sutures be cut very close to the knot so as to leave the least possible amount of suture material in the tissues. Our observations have indicated, however, that, as a general rule, a knot which is reliable will hold regardless of how short the ends are cut* and a knot which slips will continue to slip more or less indefinitely (Table XIII). Thus, with a square knot in untreated silk or a triple-throw knot

TABLE XIII

EFFECT OF THE LENGTH OF THE CUT ENDS UPON THE RELIABILITY OF THE KNOT; TENSILE STRENGTH OF A SINGLE SUTURE IN MUSLIN; FIGURES ARE THE AVERAGE OF 2:6 DETERMINATIONS

SUTURE MATERIAL	TYPE OF KNOT	LENGTH OF CUT ENDS	TENSILE STRENGTH	REMARKS
No. 3 twist (plain)	Square	½ mm.	4½ lb.	Broke
		1 mm.	4½ lb.	Broke
No. 0 braid (plain)	Square	1 mm.	3¾ lb.	Broke or untied
		2 mm.	3¼ lb.	Broke or untied
		3 mm.	3¼ lb.	Broke
No. 3 twist (vaseline)	Square	½ mm.	3½ lb.	Broke or untied
		1 mm.	4½ lb.	Broke
No. 3 twist (liquid petrolatum)	Square	1 mm.	5¾ lb.	Broke
No. 3 twist ("serum-proof")	Square	½ mm.	1 lb.	Untied
		1 mm.	1 lb.	Untied
		2 mm.	1⅛ lb.	Untied
		3 mm.	1 lb.	Untied
	Triple-throw	1 cm.	1¼ lb.	Untied
		½ mm.	2 lb.	Untied
		1 mm.	1¼ lb.	Untied
		2 mm.	2 lb.	Untied
		5 mm.	3 lb.	Broke after slipping 0.5 cm.
		1 cm.	4 lb.	Broke after slipping 0.5 cm.
No. 0 braid ("serum-proof")	Square	1 mm.	1¼ lb.	Untied
		3 mm.	1¼ lb.	Untied
		5 mm.	1¼ lb.	Untied
	Triple-throw	1 mm.	2½ lb.	Untied
		3 mm.	3¼ lb.	Untied
		5 mm.	4 lb.	Broke after slipping 3 mm.

in vaselined silk, the ends may safely be cut very close to the knot; whereas, if the silk is waxed or "serum-proofed," the knots may become untied under tension even if the ends are left 5 mm. or more in length.

Similar tests were made with catgut, for it is rather generally agreed that these knots should be safeguarded by leaving fairly long ends. It was observed that here also the length of the cut ends was of dis-

*To within 0.5 mm. in the case of fine silk.

tinctly minor importance as compared to the type of knot and type of catgut used. Square knots in plain catgut slip and become untied when the ends are cut as far as 2 cm. away from the knot and the triple-throw knot tied in chromic gut will hold even if the ends are only 2 mm. long (Table XIV). It seems apparent that one cannot

TABLE XIV

RELIABILITY OF CATGUT KNOTS AS AFFECTED BY LENGTH OF CUT ENDS; TENSILE STRENGTH OF THREE INTERRUPTED SUTURES IN MUSLIN TESTED AFTER SOAKING IN PHYSIOLOGIC SALINE SOLUTION

SUTURE MATERIAL	DURATION OF SOAK	TYPE OF KNOT	LENGTH OF CUT ENDS	TENSILE STRENGTH	REMARKS
No. 000 plain catgut (tensile strength 5¼)	1 min.	Square	1 cm.	3½ lb.	Untied
		Triple-throw	5 mm.	10 lb.	Broke
	48 hr.	Square	1 cm.	2¾ lb.	Untied
		Triple-throw	1 mm.	6 lb.	2 untied
	6 days	Square	2 cm.	3½ lb.	Untied
		Triple-throw	1 mm.	7¾ lb.	1 untied
			5 mm.	9¼ lb.	Broke
			1 cm.	6½ lb.	1 untied
No. 000 chromic catgut (tensile strength 5¼)	1 min.	Square	1 mm.	10½ lb.	Broke
	48 hr.	Square	1 mm.	9½ lb.	Broke
			2 mm.	11 lb.	Broke
			1 cm.	10½ lb.	Broke
	6 days	Square	2 mm.	9¼ lb.	Broke
		Triple-throw	2 mm.	9½ lb.	Broke
No. 0 plain catgut (tensile strength 10)	2 hr.	Square	2 mm.	2 lb.	Untied
			3 mm.	2¼ lb.	Untied
			1 cm.	1 lb.	Untied
		Triple-throw	2 mm.	13 lb.	Broke
No. 0 chromic catgut (tensile strength 9½)	2 hr.	Square	3 mm.	2 lb.	Untied
			1 cm.	2 lb.	Untied
		Triple-throw	3 mm.	14 lb.	Broke
No. 3 silk twist (tensile strength 2¼)	48 hr.	Square	1 mm.	13½ lb.	Broke
	6 days	Square	1 mm.	12½ lb.	Broke
No. 3 twist ("serum-proof")	6 days	Triple-throw	1 mm.	8¾ lb.	2 untied

depend upon long ends to protect the knot, but rather that one should employ a type of knot which is reliable for the particular suture material used. Suture material should be avoided where the most reliable of the surgical knots, the triple-throw knot, fails to hold. Even if knots could be relied upon to tighten and hold after slipping for a certain distance, accurate approximation of the tissues would be lost and the surgeon's technique would thereby lose precision. These observations with catgut lead us to the conclusion that the triple-throw knot should always be employed for plain catgut and for the larger sizes of chromic catgut; whereas, for the smaller sizes of chromic gut the square knot may be relied upon. In either case there is little advantage in leaving the cut ends longer than 2 or 3 mm.

To return to silk, it is interesting to note that with the twisted silk knots appear to hold better than with the braided. The "surgeon's knot" shows little superiority over the ordinary square knot as regards the holding power of the knot, but it has the advantage, which may in certain circumstances be very important, that the first throw will stay in place without maintaining tension on the suture. This permits the accurate placing of ties on delicate and friable tissues.

Size of Suture.—Published descriptions of the silk technique generally advise the use of "fine silk," but all too often the exact sizes are not stated. Moreover, the various manufacturers employ widely different scales of size terminology so that, unless the brand and type of silk are specified, the size number or letter is meaningless (Table XV). This has led many surgeons who are adopting the silk technique to employ silk which is unnecessarily heavy, a practice which may lead to trouble if the wound suppurates.

TABLE XV

SHOWING THE COMPLETE LACK OF UNIFORMITY IN THE SIZE TERMINOLOGY OF SUTURE MATERIALS

APPROXIMATE DIAMETER	APPROXIMATE TENSILE STRENGTH	BELDEN TWIST	CHAMPION		DEKNATEL	CATGUT
			TWIST	BRAID		
0.0025 in.	½ lb.			000 000	A	
0.003 in.	1½ lb.		1	00	B	
0.005 in.	3 lb.	A	3	0	C	000 00
0.007 in.	3¾ lb.		4	1	D	
0.008 in.	4 lb.			2		
0.009 in.	4½ lb.	C	6	3	1	000
0.010 in.	5 lb.	D	7	4		
0.011 in.	8 lb.		10	5		00
0.012 in.				6	2	
0.013 in.	10 lb.		13	7		0
0.015 in.				8	3	1
0.018 in.	12 lb.			9	4	2
0.021 in.	16 lb.			12	5	3
0.023 in.	20 lb.			18	6	4
0.027 in.	30 lb.			19	7	5

The strength of suture material to be employed should logically depend upon the holding power of the tissue into which the suture is placed. Howes and Harvey[8] have pointed out that nothing is gained by using a suture with a tensile strength greater than the holding power of the tissue. This does not mean, however, that the tensile strength of the suture material should be the same as the holding power of the tissue, because a single interrupted stitch uniting the tissues consists of two strands between the tissues. On the other hand, the strength of the stitch is not twice that of a single strand, because one of the two strands contains the knot which, because of shearing

action, is weaker than the intact strand. Tests show that the strength of a silk stitch is about 75 per cent greater than the tensile strength of a single strand of the silk.

With catgut we must allow for the progressive loss of tensile strength of the suture in the tissues.[8] Since this does not have to be considered in the case of silk, at least during the early period of wound repair when the strength of the stitches is an important factor, we may conclude that the proper size of suture is one with a tensile strength only 55 to 60 per cent of the holding power of the tissue.

In our hands the holding power of the various tissues has proved to be considerably less than was found by Howes and Harvey (Table XVI). According to our tests, a silk thread with a tensile strength

TABLE XVI

HOLDING POWER OF THE VARIOUS TISSUES AS TESTED BY A SINGLE SUTURE OF NO. 3 SILK TWIST (TENSILE STRENGTH OF THIS STITCH IS 4½ LB.)

TISSUE	DOG	HUMAN
Anterior rectus sheath (as in longitudinal incision)	4 lb.	2¾ lb.
Anterior rectus sheath (as in transverse incision)	4½ lb.	2½ lb.
Rectus muscle (as in longitudinal incision)	2 lb.	
Rectus muscle (as in transverse incision)	2 lb.	1¾ lb.
Median nerve (stitch placed in epineurium)		1½ lb.
Wrist tendon (stitch placed in epitenon)	⅞ lb.	⅝ lb.
Peritoneum and transverse fascia		1¼ lb.
Posterior rectus sheath (upper abdomen)		1 lb.
Posterior sheath with peritoneum and transversalis fascia (upper abdomen)	1¼ lb.	
Subcutaneous fat	1 lb.	
Subcutaneous fat with superficial fascia	2½ lb.	
Small bowel		
Serosa	¼ lb.	
Serosa and submucosa	⅞ lb.	
All layers	⅝ lb.	

of only one and one-fourth pounds (i.e., champion twist No. 0) should be strong enough even for fascial stitches because the strength of the stitch itself is two and one-fourth pounds. For practical purposes, however, silk as fine as this is difficult to use because it breaks too readily on tying. Therefore, as routine material for sutures and hemostatic ties a strand about 0.005 inch in diameter with a tensile strength of approximately three pounds is recommended (Table XV). The only occasion for using heavier silk would be for mass ligatures, which are to be avoided, or for pulling together structures which cannot easily be approximated. In the latter instance the fate of the suture line would still be dubious, however, because the constant tension would cause the stitches gradually to cut through.[9] It might seem that larger sizes would show less tendency to cut through the tissue. Our tests, however, in agreement with the findings of Howes and Harvey,

[8] Mason and Shearon[5] found that tendons sutured with silk separated about one inch even when the limb was fixed in a position of relaxation, apparently due to the constant slight muscle pull.

show that this is not the case. A No. 13 silk twist with a diameter of 0.013 inch tears through tissue at the same pull as does a No. 0 twist with a diameter of only 0.003 inch.

Technique of Suturing.—How close together should the stitches be placed in a suture line? Howes and Harvey considered this problem briefly in their studies with catgut and concluded that "little strength is gained by multiplying the number of interrupted sutures in a given area." This would seem theoretically to be rather surprising because the strength of a suture line depends upon two factors, the holding power of the tissue and the strength of the stitches, and both of these factors are directly affected by the number of stitches in a given area.

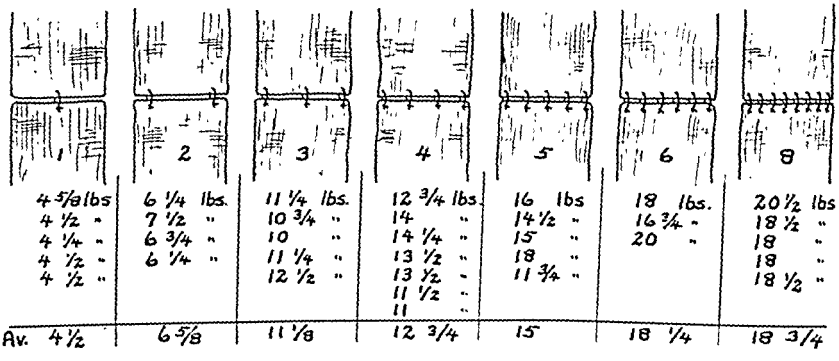


Fig. 2.—Effect of multiplication of sutures on strength of suture line, where suture is weaker than tissue. Interrupted sutures of champion twist No. 3 (untreated, wet, tensile strength 2⅝ lb.) placed in muslin.

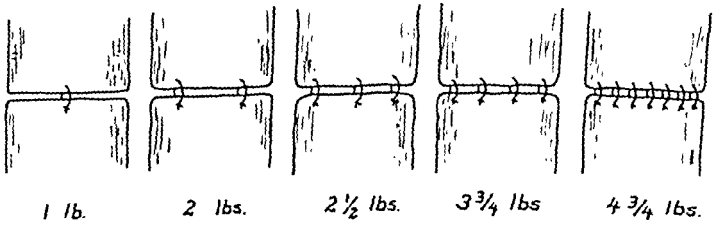


Fig. 3.—Effect of multiplication of sutures on strength of suture line, where suture is stronger than tissue. Interrupted stitches of champion twist No. 0 (untreated, wet, tensile strength 1¼ lb.) placed in weak cloth.

The strength of the suture line does not increase in mathematical proportion with an increase in the number of stitches, probably because the strain is not evenly distributed, but certainly a great increase in strength is gained (Figs. 2 and 3). There is a further advantage in placing a relatively large number of stitches in that a more accurate approximation is attained. This is especially important where the tissues are brought together under a certain amount of tension or where there is likely to be tension during the process of repair. Thus the optimum frequency of stitches depends upon the number required

for accurate approximation and upon the strength required of the suture line, for, as has been shown, the strength of the suture line can be increased only by increasing the number of stitches and not by employing heavier suture material. The number of stitches indicated will, therefore, vary widely according to the circumstances. In some instances they will best be placed only a few millimeters apart.

These observations apply to a continuous suture as well. A continuous suture is stronger than a row of interrupted sutures with a corresponding number of stitches because there are only two knots to weaken the structure and because the tension is more evenly distributed among the individual bites. There are, however, the obvious disadvantages that a defect and break in the strand will forfeit the whole suture line and that the larger single piece of foreign material may, in case of suppuration, cause more trouble than would the smaller fragments.

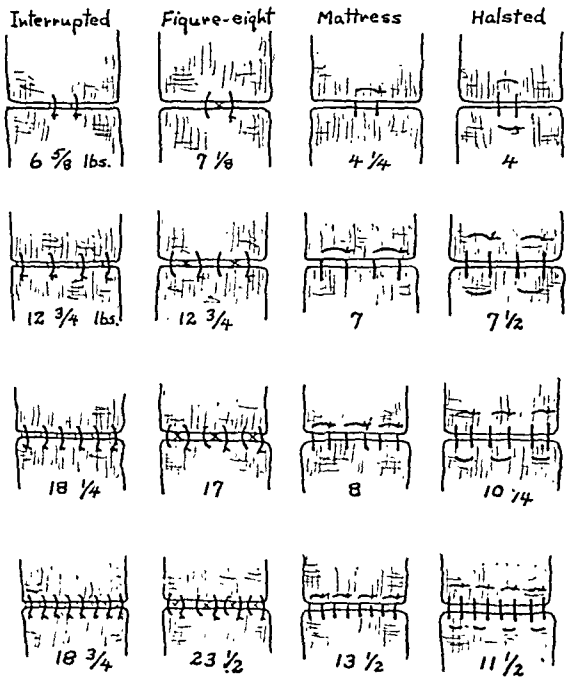


Fig. 1.—Holding power of the various stitches, where suture is weaker than tissue (champion twist No. 3 placed in muslin).

What are the relative merits of the various types of stitches? To answer this question we must consider separately two factors: the strength of the suture material and the holding power of the tissue. Where the holding power of the tissue is relatively great, a figure-of-eight stitch shows approximately the same strength as two simple stitches because in either case the tissues are united by four strands of suture. Since there is only one knot in the figure-of-eight, however,

one would expect a slightly greater tensile strength and such indeed proves to be the case, although the difference is not important. The mattress stitch is weaker than the figure-of-eight because there are only two strands uniting the tissues and accordingly it is no stronger than a single simple stitch. (Fig. 4.) On the other hand, when we are dealing with tissue with poor holding power, we find that the number of strands uniting the tissues is not as important as the number of points where the tissue is engaged by the stitch. In this case, therefore, the mattress stitch is stronger than a simple stitch but neither the mattress nor the figure-of-eight has any advantage over two simple stitches. (Fig. 5.) The mattress and Halsted types of stitches have special advantages in obtaining a wider area of contact between the tissues, and so, of course, have their definite indications, but, as far as the strength of the suture line is concerned, a row of simple interrupted stitches is just as satisfactory as a series of figure-of-eight stitches and is definitely superior to a series of mattress stitches.

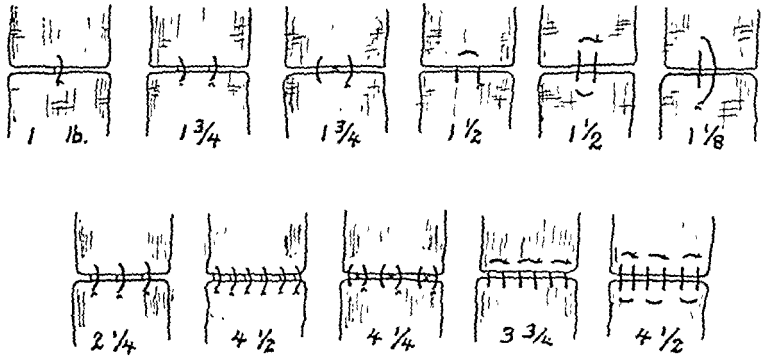


Fig. 5.—Holding power of the various stitches, where suture is stronger than the tissue (champion twist No. 3 placed in rotted cotton cloth).

CONCLUSIONS

1. Silk is not weakened by sterilization but loses strength by about one-fourth when it is wet. Autoclaving is therefore preferable to boiling since the silk is dry when used.

2. The square knot is reliable only in the case of untreated silk.

3. Lubrication is usually desirable to prevent fraying and breaking, especially where knots must be tied under tension.

4. Oiling with vaseline or mineral oil prevents fraying, but the knots do not slide down perfectly.

5. Treatment with beeswax gives ideal lubrication but only at the expense of the holding power of the knot.

6. A reliable knot cannot be tied in silk which has been treated with wax alone; even the triple-throw knot fails to hold.

7. A satisfactory lubricant is a mixture of wax and vaseline which is best applied by smearing a small amount on the board on which

the silk is subsequently wound. As the silk is autoclaved, the lubricant distributes itself evenly over the strands.

8. Bacteriologic tests show that silk thus prepared is reliably sterile.

9. With silk treated in this manner, the square knot is not reliable, but the triple-throw knot will hold satisfactorily.

10. Fine silk (diameter, 0.005 inch; tensile strength, three pounds) is amply strong for routine use, including fascial suturing.

11. Increased strength in the suture line may be obtained not by employing heavier suture material but by increasing the number of individual stitches in a given area.

12. A suture line of simple interrupted stitches is approximately as strong as one of figure-of-eight stitches and stronger than one of mattress stitches.

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THE IMMEDIATE STRENGTH OF THE SUTURED WOUND*†

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THIS paper is an attempt to explain the degree of strength which can be given to the repair of a wound by means of sutures.

The common belief is that the strength of the sutured wound is dependent on the thread strength of the sutures employed to hold the tissues together. Actually, the number of sutures employed is a contributing factor, but the holding power of the tissue really determines the strength of the union and the strength of the sutures in the wound is much less than generally supposed. For example, when sutures are placed in a wound, they lose strength both by wetting with tissue fluids and by knotting. By wetting they lose about 30 per cent of their original dry-thread strength. Catgut with a dry-thread strength of 21 pounds decreases to 15 pounds, while silk with a dry-thread strength of 3.1 pounds decreases to 2.2 pounds. Linen does not lose strength by wetting alone, but when boiled five minutes, and then wet, linen also loses 30 per cent of dry-thread strength. Knotting causes a loss of 40 to 50 per cent of dry-thread strength, while wetting and knotting cause a loss of approximately 50 to 60 per cent. The residual or functionating strength is, therefore, only about 40 or 50 per cent of the original dry-thread strength (Table I) and unfortunately this residual or functionating strength is not always proportional to original dry-thread strength. Thus, the functionating strengths of Nos. 2 and 3 catguts are not proportional to the dry-thread strengths (Table I) and are in fact no greater than functionating strength of No. 1. For silk the functionating strengths are somewhat more proportional to the dry-thread strengths, but still the loss of strength which all kinds of sutures sustain by insertion into the wound is of such magnitude that the residual strengths do not have the supposed advantages indicated by the original dry-thread strengths. The entire range of strength for the different sizes is contracted and the variations between the sizes reduced in amount. For instance, the functionating strengths of the different sizes of catgut No. 00 to No. 3 vary only from 2 to 8.51 pounds, or a difference of 6.5 pounds for the entire range; while the dry-thread strengths extend from 5.7 to 23 pounds, a range of 17.3 pounds. With silk the functionating strengths vary only from 1.7 to 4.9 pounds from Nos. A to E, a difference of 3 pounds, while the dry strengths range from 3 to 8.4 pounds, or a difference of 5½ pounds. Because of this contraction in the range of strength and because of the lack

Received for publication, June 12, 1939.

*Presented at the meeting of University Surgeons, Rochester, N. Y., Feb. 11, 1939.

†Part of this work was done in the Department of Surgery, Yale University, New Haven, Conn., with the technical assistance of Miss Cornelia Hewitt.

TABLE I

BREAKING STRENGTH AFTER WETTING AND KNOTTING CATGUT AND SILK POUNDS

	Catgut					
SIZES	NO. 000	NO. 00	NO. 0	NO. 1	NO. 2	NO. 3
Dry Normal—*pounds*	Avg., 5.7	Avg., 6.2	Avg., 10.9	Avg., 17.0	Avg., 18.3	Avg., 23.9
Wet (30 min.) Knotted Tested wet	Avg., 2.3	Avg., 2.5	Avg., 4.3	Avg., 7.3	Avg., 7.1	Avg., 6.3
Wet (2 hr.) Knotted Tested wet		Avg., 2.2	Avg., 4.2	Avg., 8.5	Avg., 8.5	Avg., 8.1
Percentage of original strength		36	35	50	35	35

	*Silk**					
SIZES	NO. 000	NO. 00	NO. 0	NO. A	NO. C	NO. E
Dry Normal	Avg., 3.3	Avg., 6.0	Avg., 8.4	Avg., 3.5	Avg., 4.5	Avg., 8.0
Wet (30 min.) Knotted	Avg., 1.7	Avg., 3.5	Avg., 4.0	Avg., 2.0	Avg., 2.0	Avg., 4.4
Percentage of original strength	51	58	47	57	60	55

*The gradation of silk according to sizes is very confusing. Some manufacturers indicate sizes by letters, some employ a gradation corresponding to catgut sizes, while others have an absolutely unrelated system. Throughout the text of this article, the size of catgut is usually quoted and any gradation of silk may be applied when the strength corresponds.

of proportion to the dry-thread strengths, the functionating strength of a suture is a better guide to the usefulness of that suture than the dry-thread strength.

The principal reason, however, why the strength of the sutured wound is not dependent on strength of the sutures used is because the holding powers of tissues for the sutures are, in most instances, less than the functionating strengths of the sutures and the holding powers are not in any way influenced by the thread strengths of the sutures employed. The holding powers of tissues were determined in the following manner: The tissue to be investigated was secured in one clamp of a tensile strength machine and the stitch inserted about 0.5 cm. deep into its substance in such a way that the suture had to be pulled out at right angles to the direction of the fibers of the tissue. The free ends of the stitch were placed in the other clamp of the machine to obtain the necessary traction. In this way the holding power of the tissues was compared with the dry-thread strengths of the different sizes of sutures. The constancy of the amount of holding power possessed by each tissue regardless of the size of the suture used is illustrated in Table II. Muscle had a holding power of 2.8 pounds, regardless of whether size No. 3 or size No. 00 catgut was used; while fascia had a holding power of 8.3 pounds with size No. 0 or

any larger suture. Fascia,* as would be expected, possessed the greatest amount of holding power, while fat had the least. On the other hand, when the stitch was pulled out parallel to the fibers of the tissues, holding power fell markedly; that for fascia diminished to 2 pounds, for example, while that for muscle was almost negligible. It should be noted, however, that the tendinous inscriptions of muscles have a holding power similar to fascia.

TABLE II

HOLDING POWER OF TISSUES FOR DIFFERENT SIZE OF CATGUT*

TISSUE†	SIZE OF SUTURE	AVERAGE DRY TENSILE STRENGTH (POUNDS)	HOLDING POWER (POUNDS)
Fat	00	6.2	0.4
	0	10.0	0.6
	1	16.0	0.5
	2	18.3	0.3
	3	23.9	0.4
		Average	0.44
Peritoneum postsheath	00		2.3
	0		2.3
	1		1.8
	2		2.0
	3		1.8
			1.9
Muscle	00		3.0
	0		3.0
	1		2.8
	2		2.6
	3		3.0
			2.8
Fascia	00		Suture broke, no test
	0		8.2
	1		9.0
	2		7.8
	3		8.1
			8.3

*In all tests except one, the tissue tore, signifying that the strengths obtained were holding powers.

†Same structure, i.e., particular muscle or fascia, used in each test. When different fasciae were used, holding powers varied from 3 to 8.5 pounds. There is very little variability in holding powers of different muscles except in tendinous inscriptions.

It would seem, therefore, that the capacity of a tissue to hold a suture is determined by the component of fibrous tissue present in that tissue, its density, and the manner in which the suture pulls against the architectural arrangement and not by the strength of the suture used unless this strength is less than the holding power of the tissue. Fat has a loose and sparse component of fibrous connective tissue and little holding power, while fascia is dense fibrous tissue and has a large amount of holding power, providing, of course, the sutures pull at right angles to the fibers. In the repair of wounds the sutures frequently have to pull

*When all tissues are included and not just soft tissues, drilled bone and ligamentous structures exceed fascia in holding-power strengths.

parallel to the tissue fibers and unfortunately such unions are weak, regardless of the strength of the sutures used. For example, the sutured union of the posterior sheath of the rectus muscle in the repair of the longitudinal incision in the anterior abdominal wall never can be made as strong as the repair of the anterior sheath, regardless of the strength of the sutures used. In the posterior sheath, the fibers in general run transversely, and the sutures pull out parallel to them; while in the anterior sheath the fibers mostly run longitudinally and the sutures pull at right angles to them. In the same way the full holding power of tendon can never be entirely utilized, because, in spite of the ingenious types of sutures which have been devised, they all pull out more or less parallel to the collagenous bundles of the tendon.

In Table III the functionating strengths of the various sizes of sutures are compared to the holding powers of the various tissues. In the last column is the determinant of the strength of the union, based on whether the functionating strength of the suture is greater or less than the holding power of that particular tissue. It will be noted that in all tissues except fascia the strength of the union is determined by holding power of the tissues and that this strength is less than the functionating strength of the sutures usually employed, beginning with size No. 00. In fascia,

TABLE III

COMPARISON OF HOLDING POWER AND FUNCTIONATING STRENGTH OF SUTURES (SINGLE BITE)

TISSUES	AVERAGE HOLDING POWER	FUNCTIONATING STRENGTHS, SINGLE SUTURE		DETERMINATION OF STRENGTH OF UNION
		Catgut	*Silk*	
Fat	0.44 lb.	00-2.2	00-3.5	Holding power
		0 -4.2	0 -4.0	Holding power
		1 -8.5		Holding power
		2 -8.5		Holding power
		3 -8.5		Holding power
Peritoneum and post-sheath	1.9 lb.	00-2.2	00-3.5	Holding power
		0 -4.2	0 -4.0	Holding power
		1 -8.5		Holding power
		2 -8.5		Holding power
		3 -8.5		Holding power
Muscle	2.8 lb.	00-2.2	00-3.5	Suture*
		0 -4.2	0 -4.0	Holding power
		1 -8.5		Holding power
		2 -8.5		Holding power
		3 -8.5		Holding power
Fascia	3-8.3 lb.	00-2.2	00-3.5	Suture*
		0 -4.2	0 -4.0	Suture*
		1 -8.5		Holding power
		2 -8.5		Holding power
		3 -8.5		Holding power
		4 -8.5		Holding power

*See text for determinant when multiple sutures are used.

any larger suture. Fascia,* as would be expected, possessed the greatest amount of holding power, while fat had the least. On the other hand, when the stitch was pulled out parallel to the fibers of the tissues, holding power fell markedly; that for fascia diminished to 2 pounds, for example, while that for muscle was almost negligible. It should be noted, however, that the tendinous inscriptions of muscles have a holding power similar to fascia.

TABLE II

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TISSUE†	SIZE OF SUTURE	AVERAGE DRY TENSILE STRENGTH (POUNDS)	HOLDING POWER (POUNDS)
Fat	00	6.2	0.4
	0	10.0	0.6
	1	16.0	0.5
	2	18.3	0.3
	3	23.9	0.4
		Average	0.44
Peritoneum postsheath	00		2.3
	0		2.3
	1		1.8
	2		2.0
	3		1.8
			1.9
Muscle	00		3.0
	0		3.0
	1		2.8
	2		2.6
	3		3.0
			2.8
Fascia	00		Suture broke, no test
	0		8.2
	1		9.0
	2		7.8
	3		8.1
			8.3

*In all tests except one, the tissue tore, signifying that the strengths obtained were holding powers.

†Same structure, i.e., particular muscle or fascia, used in each test. When different fasciae were used, holding powers varied from 3 to 8.5 pounds. There is very little variability in holding powers of different muscles except in tendinous inscriptions.

It would seem, therefore, that the capacity of a tissue to hold a suture is determined by the component of fibrous tissue present in that tissue, its density, and the manner in which the suture pulls against the architectural arrangement and not by the strength of the suture used unless this strength is less than the holding power of the tissue. Fat has a loose and sparse component of fibrous connective tissue and little holding power, while fascia is dense fibrous tissue and has a large amount of holding power, providing, of course, the sutures pull at right angles to the fibers. In the repair of wounds the sutures frequently have to pull

*When all tissues are included and not just soft tissues, drilled bone and ligamentous structures exceed fascia in holding-power strengths.

suture of insufficient functionating strength, providing, of course, that an adequate number of sutures is used.

TABLE IV

INCREASE OF HOLDING POWER (*A*) AND FUNCTIONAL STRENGTH (*B*) BY INCREASING THE NUMBER OF SUTURES USED

A.	1 interrupted suture, No. E silk in fascia equals 3.0 lb.
	2 interrupted sutures, No. E silk in fascia equals 3.9 lb.
	3 interrupted sutures, No. E silk in fascia equals 5.0 lb.
	8 interrupted sutures, No. E silk in fascia equals 9.0 lb.
	8 interrupted sutures, No. C silk in fascia equals 9.0 lb.
	8 interrupted sutures, No. A silk in fascia equals 8.5 lb.
B.	Knotted, size No. 0 catgut
	1 strand equals 4.1 lb.
	2 strands equal 8.0 lb.
	3 strands equal 12.0 lb., etc.

Again it will be noted in Table IV that the holding power of the tissue is not influenced by the strength of sutures used even when they are multiple. Eight large silk sutures (No. E) contributed no more strength to the sutured union than eight fine sutures (No. A) with a functionating strength less than the holding power of the tissue.

The question whether a stronger closure of the wound results from the use of a continuous suture or from the use of interrupted sutures has also been considered. In the last analysis the continuous variety is only another form of multiple sutures, so all the arguments just used for the relationship of functionating strength to holding power apply; namely, that the holding power is the limiting factor. However, it might be argued that the continuous variety suffers less loss of strength than the interrupted variety, because there are fewer knots in it in proportion to the number of bites of tissue and knotting causes the loss of thread strength. The relative strength of the two types was therefore estimated in the following manner: An equal length of the skin of the dog which has an excessive amount of holding power was closed, in one instance, with a number of interrupted sutures of fine size and next by a continuous suture of the same size with a number of loops corresponding to the number of interrupted sutures. Thus, a continuous suture of four loops and two knots was compared to four interrupted sutures with four knots and a continuous suture of six loops and two knots was compared with six interrupted sutures and six knots (Table V). The results failed to show that the strength of the repair sutured with the continuous variety was in any way superior to the closure with interrupted sutures. The explanation is quite simple. In the continuous variety the entire tension is divided between the strands and finally distributed to the weakest knot which disrupts, and, in the case of the interrupted sutures, the tension is distributed between the same number of strands and again the weakest knot breaks. The skin, as was pointed out, is ex-

however, the holding power exceeds the functionating strength of size No. 0; but, again, when the suture pulls parallel to its fibers, the functionating strength of No. 00 is greater. In every instance, therefore, except in fascia, the tissues hold the sutures and not the sutures the tissues, and the corollary is equally as true, that the strength of the wound can never be greater than the holding power of tissues for the sutures. A crude simile will perhaps illustrate the situation: two pieces of cheese cloth cannot be sewed together any more securely with rope than with thread, for the flimsy mesh of the cloth has no greater holding power for the larger and stronger strand than for the smaller one. Even in fascia, holding power definitely limits the strength of the sutured union when a suture of sufficient functionating strength is employed. In this tissue it is only with the finest sizes Nos. 000 and 00 that the limiting strength set by holding power is reduced by insufficient functionating strength, and actually this does not happen when the relationship of holding power to functionating strength is considered for multiple sutures.

The degree to which holding power is increased by using many sutures has been studied as follows: A constant length of abdominal wall of the rabbit, skin not included, was secured with an increasing number of sutures possessing excessive functionating strength in the single stitch and the strength of the union determined by pulling the edges apart. Each suture was placed 1 cm. deep. The tissues tore each time, indicating the strengths obtained were those of holding power. Table IV shows that the holding power for two stitches is not double that for one, but that an increment of strength is added by each additional suture until a maximum strength is reached with a concentration of sutures approximately 0.5 cm. apart. Additional holding power was not obtained by placing the sutures closer together. On the other hand, the functionating strength of two sutures was double that of one, four of two, etc. Now, considering that holding power does not increase in direct proportion to the number of sutures used, while functionating strength does, it is obvious that the ratio of functionating strength to holding power constantly increases as each suture is added to the wound. To state the circumstances in another way, the tension or strain which must be overcome to hold the wound edges together is divided into smaller portions as the number of sutures is increased and the stress thrown onto each one of the sutures becomes less with the addition of every new one. Moreover, there is apparently no limit to the division which can be obtained by increasing the number of sutures, while holding power soon reaches a maximum with a definite concentration of sutures. Holding power, therefore, becomes more and more of a limiting factor when many sutures are used and yet, when many sutures are used, less strength is required of each one. For this reason, there is little danger of reducing the maximum strength of the union set by the holding power of fascia by using a

impossible to preserve the continuity of cut edges for any considerable length of time when tissue death or atrophy of tissue occurs. It is absolutely essential, therefore, even from the point of view of the strength of the repair that the method of suturing preserves the viability of the tissues, and, of course, it is absolutely necessary for obtaining satisfactory wound healing.

In conclusion, as far as strength is concerned, and this discussion has been entirely devoted to strength, there is no need of suturing any other tissue but fascia, except to eliminate dead space or in the case of the peritoneum to prevent herniation. Moreover, when multiple sutures are used, there is no need to use a suture with a functional strength stronger than No. 0 catgut, because the holding-power strengths of all tissues are less and really limit the strength of the repair. The use of any larger suture simply provides an excess amount of foreign material, no greater strength, and presents the possibility of untoward wound healing. Increasing the number of sutures employed increases the amount of holding power of the tissues, but, more important still, increases in direct proportion the functionating strength of the sutures, providing a better ratio of functionating strength of holding power. Less strain is, therefore, thrown on each suture. Increasing the bite of tissue enhances holding power to a slight degree, but only in fascia. The danger of tissue necrosis is so great with the use of the deep-bite suture that it should only be used sparingly, and better healing is usually obtained when it is not used. When sutures are going to pull out parallel to the fibers of the tissues, the repair will be weak and special attention must be given to increasing the holding power of these tissues either by using mattress sutures or by constructing the wound in such a manner that the fibers will not be cut across. Incisions of the exterior abdominal wall which split the fibers and do not cut them recently have been advocated again by Singleton.[2] Interrupted sutures are recommended because the strength of each unit is preserved when the suture material is being absorbed or holding power lost in one portion of a wound and not because they give greater strength than the continuous suture. Under similar conditions the integrity of continuous suture would be entirely lost.

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ceptionally strong and forced the sutures to tear in these special tests. In most instances the tissue itself would have torn.

From another viewpoint though, interrupted sutures have a distinct advantage over a continuous type. If during the healing of the wound the knot of the continuous variety breaks or the strand itself disintegrates or the holding power of the tissues for one loop is destroyed in any one place, then the whole integrity of the union is threatened. With interrupted sutures, on the other hand, each suture is a separate unit of strength and if the integrity of one is lost the others carry on their intended functions.

The extent of the bite of the suture or the depth to which it is inserted into the tissue naturally influences the amount of holding power of that tissue, but only in those which possess a fair degree of holding power for a bite of any depth. In fascia, for example, a bite of 1 cm. has a holding power of 5 pounds, while in the same fascia a bite of 0.5 cm. has a holding power of 7 pounds. In muscle and fat, to the contrary, an increase of the bite to the same depth contributed only a negligible increase in strength. This increase of strength with the larger bite in fascia is without advantage, moreover, for the larger bite leaves behind an un-

TABLE V*

INTERRUPTED SUTURES		CONTINUOUS SUTURES	
No. 4—4 knots	13.0 lb.	4 loops	7.2 lb.
	10.0 lb.	2 knots	16.0 lb.
	17.5 lb.		16.5 lb.
	13.5 lb.		10.0 lb.
Average	13.0 lb.		12.1 lb.
No. 6—6 knots	19.0 lb.	6 loops	23.5 lb.
	14.5 lb.		7.0 lb.
	15.0 lb.	2 knots	11.0 lb.
	15.3 lb.		14.0 lb.
Average	15.8 lb.		13.8 lb.

*No. 00 catgut used throughout. Sutures broke in all tests.

necessary amount of suture material or foreign body in the wound without a remarkable gain in strength. With the employment of the larger bite, also, there is a tendency to tie the sutures tighter causing strangulation of the tissue and necrosis.

Last, there are certain features in the actual suturing of the wound clinically which cannot be evaluated mechanically from the suturing of two detached pieces of dead flesh. In the wound part of the strain preventing separation of the edges is born by the intact and uninjured tissues at either end of the defect. More important still, the tissues about the wound are living and tend to splint the area of separation during the first few days of healing and to contract and lessen the size of the defect and the tension across it in the later days of the repair. The vitality of the tissue maintains the holding power of the tissue, and, in fact, it is

stances biopsies were made from the wound sites approximately five days after operation, and the cutaneous incisions again closed.

The animals died or were killed at varying intervals following the operation. A study of the gross contour of the neoplasms was made with reference to any bulges in the regions where the wounds were made or to other evidence that the neoplastic tissue was proliferating or infiltrating surrounding normal tissues at a greater rate in these regions than elsewhere. Oblong blocks of tissue were taken at right angles to the long axes of the wounds for microscopic study, after death of the animals.

Eighteen neoplasms were operated upon, with three immediate deaths, leaving fifteen for study. The latter died or were killed from one to thirty-five days after operation. Seven survived the operation twenty to thirty-five days.

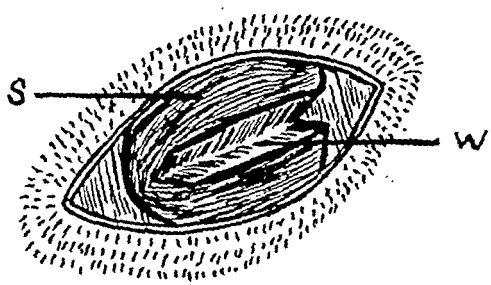


Fig. 1.—Diagrammatic illustration to show manner of making wedge-shaped wounds in experimental sarcomas. *S*, Sarcoma of subcutaneous tissue produced by injection of methylcholanthrene; *W*, wedge-shaped wound in the neoplasm.

The gross findings may be summarized as follows (Figs. 2 and 3):

1. Obliteration of the trough-like wounds occurred in approximately twelve to fourteen days by what was essentially proliferation of tissue from the wound surfaces in the tumor. There was little evidence to indicate that any appreciable healing occurred as the result of invasion by surrounding nonneoplastic tissue.

2. In some instances where the wounds had healed it was difficult to ascertain exactly the previous site of the wound.

3. A study of the entire excised tumor masses showed no evidence in any case that there was stimulation of growth in the region of the experimental wounds. These regions showed no bulges as compared with other surfaces of the tumor. In fact, where the wound region did not conform in general to the contour of the whole tumor, it presented a cicatrix which was puckered and slightly depressed below the surrounding surfaces.

4. Areas of spontaneous degeneration are very often observed in experimental sarcomas and in some cases here studied such spontaneous necrosis of tumor tissue and overlying skin occurred, but not necessarily in wound areas. In two instances such degeneration did occur

THE REACTION OF EXPERIMENTAL SARCOMAS TO THE WOUND-HEALING STIMULUS*

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PREVIOUS experimental work dealing with the possible relationship between chronic inflammation and carcinogenesis has been summarized in a recent paper by Brunschwig, Tschetter, and Bissell. The reported results have been conflicting in that in some instances chronic inflammation was thought to reinforce experimental carcinogenesis by tar; whereas, in other instances it was felt that this was not the case. The above authors observed that the wound-healing stimulus, as afforded by the creation of large ulcers with radium or the actual cautery, when applied to cutaneous epithelium which was exposed to a carcinogenic compound did not under experimental conditions hasten the formation of epidermoid carcinoma. In a more recent publication Beck observed that the appearance of sarcomas in the subcutaneous tissues of the rats was not hastened when the carcinogenic compound was injected with turpentine, the latter inducing a severe inflammatory reaction about the injected agent.

The following experiments were performed to observe whether in experimental sarcomas the addition of the wound-healing stimulus would result in an increase in the growth rate in the region of the tumors where such stimulus was applied.

Methods.—Sarcomas in the subcutaneous tissues of the backs of rats were induced by the injection of 1 to 2 mg. of methylcholanthrene suspended in 0.1 to 0.2 c.c. of lard. When the tumors appeared three to seven months after injection, they were exposed through a cutaneous incision over them, and an elongated wedge-shaped piece of the neoplasm, 2.5 to 3 cm. long and 0.7 cm. deep, was removed by sharp dissection (Fig. 1). The edges of the trough-like wound thus made in the tumor were not approximated but remained separated for a distance of about 1 cm.; the skin incision was then closed by interrupted silk sutures. The tumors varied in size when they were operated upon and the portion removed extended almost from one pole of the oval mass to the other in the smaller neoplasms, but in the moderate-sized neoplasms the length of the wound corresponded to only a segment of the total circumference of the growth. In two in-

*This work was facilitated by a grant from the Douglas Smith Foundation of the University of Chicago.
Received for publication, July 18, 1939.

true tumor cells or are immature fibroblasts arising from nonneoplastic elements of the stroma of the tumor which were stimulated to proliferation by the making of the wound. At least both neoplastic and nonneoplastic elements were taking part in this repair. The capillaries appeared to be true capillaries and not vascular spaces in buds of tumor cells.

2. By the eleventh to seventeenth day the wounds were for the most part closed and an irregular cicatricial area at the surface was present which included spindle cells that may or may not be neoplastic, frequently separated by broad bundles of collagen (not very dense). Bordering this cicatrix the tumor tissue did not appear to differ greatly from that elsewhere in the neoplasm. In some instances irregular areas of "coagulation necrosis," including "shadows" of spindle cells, were present. Edematous and necrotic tissue detritis was present over the wound sites and beneath the overlying skin.



Fig. 3.—Showing excised tumor thirty-one days after operation. *S*, Reflected skin over wound site which has healed and is represented as a puckered scar, *W*; *B*, block of tissue removed to obtain sections transversely through wound site for microscopic study.

3. Sections from tumor sites twenty to thirty-five days after operation showed essentially the same as above with perhaps a diminution of the cicatrix area. Because in these larger growths increasing numbers of areas of spontaneous degeneration occurred, it was more difficult to discern with certainty what was previously the wound area.

in the wound areas; in one case the skin and subjacent wound area became necrotic and in another case a large cystic space containing yellowish fluid developed at the wound site.

5. Measurements of the tumor were made just before operation and at death of the animal. While growth rates of the tumors varied, all of them increased gradually in size following operation. From previous experience with sarcomas produced in the manner herein described, it was the impression that no undue rapidity in growth of the whole tumor occurred after operation.

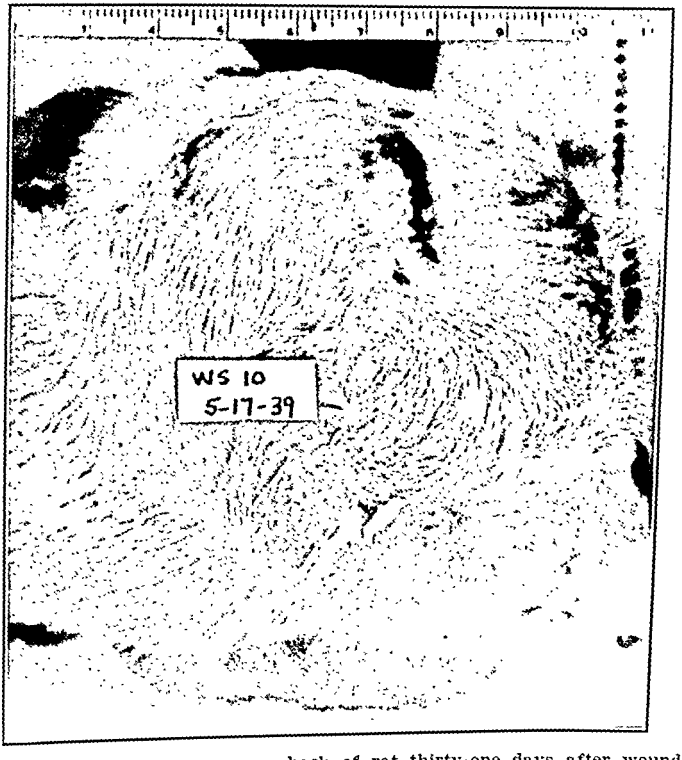


Fig. 2.—Showing large sarcoma on back of rat thirty-one days after wound was made through healed incision. Sutures had remained in the wound for purposes of marking. Note smooth symmetrical contour of the tumor mass with no bulge of tissue in the wound area.

Histologically the sarcomas were essentially fibro- or spindle-cell sarcomas of various types, with varying amounts of collagen.

Microscopic examinations of sections made transversely to the long axes of the wounds as described above may be summarized as follows:

1. By the fifth or sixth day following the operation, the tumor tissue constituting the wound edges is edematous, and there are many dilated capillaries. Spindle-shaped cells are observed to extend toward the wound at right angles to the wound surface. They have an immature appearance, but it is not possible to state whether they are

AN EXPERIMENTAL STUDY OF THE BACTERIOLOGY OF PERFORATION PERITONITIS*

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THE study of the bacteriology of peritonitis resulting from perforation of the intestinal tract has been undertaken more or less casually for a good many years, mainly by physicians and surgeons to round out the study of particular cases of this condition. But there has been much disagreement regarding the roles of the different organisms, and particularly of the certain organism, if any, which is the primary cause of the infection, and there has been little systematic investigation.

The interrelationships of the many species of bacteria in the intestinal tract are very complex. It seems unlikely that these relationships are maintained when the organisms escape into the peritoneal cavity. It has been noted that fewer species of bacteria are found in peritoneal infections than would be expected if the effect were due to a simple maintenance of the intestinal relationships after the organisms have escaped into the peritoneal cavity. The groups of organisms which survive under these conditions are quite well known, and, of these, the colon bacillus and the streptococci are the ones most commonly mentioned.

In the work under discussion, an experimental study of the subject was undertaken, the object being to discover, if possible, which intestinal organism or organisms play the primary role in establishing the infection. But, as the experiments progressed and, especially, as the colon bacillus thrust itself into greater prominence in the results, the aspects of the problem changed and other angles of the subject were investigated.

In the studies of perforation peritonitis which have been previously reported, the colon bacillus and the streptococcus have been the organisms most commonly noted, and opinion is somewhat divided as to which is the more important in establishing the infection. Pawlowsky[16] injected intestinal contents intraperitoneally into animals and found that many of the animals died; if he first sterilized the intestinal contents, few died. From this he concluded that the cause of perforation peritonitis was bacterial. Malvoz[11] thought, from a study of many cases of this condition, that *Escherichia coli* was the sole cause. Brütt,[2] Dudgeon and Mitchiner,[5] Warren,[21] and McClure and Altemeier[12] found *E. coli* to be the predominating organism in appendicitis and in the

*From a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Minnesota, 1939.
Received for publication, June 20, 1939.

DISCUSSION

Normal tissue in a relatively resting state, when subjected to mechanical trauma such as obtains when a wound is made with loss of tissue, exhibits a series of proliferative changes that occur in a more or less orderly manner, the object of which is to restore, to some extent at least, the removed tissue and to restore structural continuity. In the above studies, wounds with loss of tissue were made in soft parts sarcomas which are, of course, composed of cells that are already proliferating unrestrained by the factors which govern normal tissue growth, differentiation, and maintenance. It was observed that these wounds healed over a period of days and that, while the tumor mass was increasing in size, the superposition of the wound-healing stimulus in a given region did not result in excess stimulation of growth in these regions as compared with uninjured portions of the neoplasms. In fact, the general contour of the expanding tumor mass was maintained, and, if this was locally slightly distorted, it was in the form of a slightly depressed or puckered scar rather than a localized bulge in the mass.

While it is perhaps not possible to draw conclusions in regard to the biology of human sarcomas from the experiments reviewed above, a practical clinical inference that is suggested is that trauma to a malignant neoplasm, such as obtains when biopsy is performed, does not in itself necessarily constitute a stimulus to increased growth of the neoplasm. Where clinical observations seem to indicate that biopsy was followed by increased rate of spread, it would appear that this might be the result of seeding of tumor cells in surrounding tissue during such a procedure. The question of increasing the likelihood of metastases is another problem since this brings up the possibility of forcing tumor cells into vascular channels by an operative procedure carried out within neoplastic tissue.

SUMMARY

Wounds with loss of substance, produced in experimental soft parts sarcomas, healed in what appeared to be an orderly fashion while the tumor mass as a whole increased in size. The contour of the healing and healed portions of the sarcoma conformed to the contour of the growing tumor mass. No localized increase in growth due to the wound-healing stimulus superimposed upon the already present proliferative stimuli within the malignant cells was noted. The repair of the wounds in the neoplasms was accomplished by proliferation of cells of the tumor mass and not by ingrowth of nonneoplastic tissue from the immediate vicinity about the tumor.

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but diplococci and single forms sometimes can be found after some searching. Yeasts, algae, and fine-branched filaments occur rarely. Animal parasites are also occasionally seen, usually protozoa of the class Mastigophora, especially trichomonas. The microscopic picture of the samples used here showed the typical intestinal flora of the animals from which they were taken. Leucocytes from the animal were fairly common and in one case there was definite phagocytosis of the intestinal organisms.

After the injections, the cecal contents were planted on media, including 1:10 rabbit blood nutrient agar, and slides were made for examination for the types of organisms mentioned above. The inoculated media were examined for hemolysis after incubation, and different types of colonies were picked. Coliform organisms were kept for further study. However, since the cecal flora of a guinea pig is so very complex and since a large number of the types of organisms which make up this flora will not grow upon aerobic plates of the type used, the proportions of the aerobic organisms found upon these plates, especially of the coliform organisms and of the various types of spore-formers, are misleading, and do not in any way represent the true proportions of these organisms in the cecal contents.

The injected animals were autopsied as soon as they died, and, in some cases, if they survived for four days, they were killed and autopsied. It was found that after four days few animals died and autopsies performed after this time revealed few or no changes in the organs and cultures yielded few or no bacteria. The peritoneal fluids of the autopsied animals were inoculated onto the same media as were used for the suspensions, and slides of the fluids were made. The organs were examined and pieces were taken for microscopic study.

Animals injected with cecal suspensions (or operated as described) do not always die. Of the 74 animals treated, 33, or 46 per cent, died. This death rate varied very slightly with the species of animal injected and with the species of animal used as the source of the sample.

Early in the experiments, two very interesting features were noted. The first was the regularity with which organisms of the coliform group were isolated from the peritoneal fluids of the animals which died of the injections. These microorganisms were isolated from 51 per cent of all of the 57 animals which were autopsied and from 84 per cent of the 33 animals which died in four days; while they were isolated from only 16 per cent of the 24 animals which survived and were killed and autopsied.

Streptococci were very seldom found either in the original samples or in the peritoneal fluids of the injected animals. Careful examination of the original smears and of smears of the cultures revealed these organisms in 17 per cent of the suspensions and in 19 per cent of the animals. Attempts to procure pure cultures of the streptococci were

peritonitis resulting from perforation of the appendix. Streptococci were found to be common, but less so than coliform organisms. Theobald Smith[18] injected guinea pigs intraperitoneally with pure cultures of coliform organisms isolated from "scours" in calves and found that the animals developed a peritonitis which was often quickly fatal. Altemeier[1] reviewed the literature on the bacteriology of perforation peritonitis and presented a study of 100 cases of his own. He found that those cases which yielded a mixed flora were by far the most severe.

The object of the work here reported has been to discover, if possible, which of the intestinal organisms play the primary role in establishing perforation peritonitis. A total of twenty-six suspensions of cecal contents were injected into 40 guinea pigs, 16 rabbits, and 6 white mice. The suspensions of the cecal contents were prepared by adding approximately 10 c.c. of the cecal contents to approximately 20 c.c. of sterile physiologic saline solution. The larger particles were allowed to settle out by gravity and the supernatant liquid was injected intraperitoneally into the experimental animals. Guinea pigs received approximately 5 c.c. apiece, rabbits 10 c.c., and mice 1 c.c. The cecal contents were obtained from normal animals killed in the course of other experiments or from the human cecum at autopsy. In 12 more guinea pigs the peritonitis was produced by laparotomy and incision of the cecum, in order to approximate more closely the conditions obtained in actual perforation peritonitis. Of these 12 animals, 7, or 58 per cent, died of the infection, a percentage only slightly higher than that found among the animals inoculated with cecal contents by means of a syringe; and, since the laparotomy method was no more certain and seemed to involve factors of shock and local injury, this method was not used further. In 3 of the experiments the animals were injected with human cecal contents, and in 5 experiments with samples from rabbits; in the other 18 the cecal contents of guinea pigs were used.

The cecal flora of a normal guinea pig, as seen under the microscope, is extremely complex. Short gram-negative rods of the morphologic types of the colon typhoid group are nearly always seen but occasionally are sparse and difficult to find. Spore-bearing rods are universal and numerous. Microscopically many different types can be found: large, medium, and small; clostridial, square, and long slender types; square, pointed, or rounded ends; equatorial, terminal, or subterminal spores; and chained, paired, or single forms. Other gram-positive rods of many shapes and sizes are also rather numerous, but much less so than the spore-bearing group. In the guinea pig cecum a multitude of spiral forms, long or short, thick, or thin, with single or multiple curves, can be seen. Some are spirilla, but the majority are spirochetes, and these forms are usually so numerous as to outnumber all of the other forms. Fusiform organisms of varying sizes are common and fairly numerous. Cocci are usually few in numbers; streptococci are most easily found.

be recovered, except from the 6 animals which died from injections of the samples containing many pseudomonas. It would seem that these animals were susceptible to the few coliform organisms in the material injected. At any rate, this is clear evidence that without coliform organisms the cecal contents are not likely to give rise to a fatal peritonitis.

The symptoms, autopsy findings, and tissues of the injected animals which died showed only those features to be expected in acute peritonitis. In those animals which survived, the main findings were organization of the exudate and adhesions. The adhesions showed a tendency to localize the infection in an area of the peritoneum. This was especially notable in the laparotomized animals which survived, as the adhesions completely plugged the incisions in the cecums and walled off the infections.

Microscopic examination of the exudates indicated that organisms other than streptococci and coliform organisms disappeared rapidly, probably through the combined action of phagocytosis and lysis. It was noted that gram-positive organisms were phagocytized more extensively than the gram-negative rods, and that, as the infection proceeded, the microbial flora became continuously simpler. It was often observed in the smears that nonphagocytized organisms appeared to be swollen and pale-staining. This was interpreted as evidence of extracellular lysis, but it was impossible to make quantitative observations of this phenomenon or to determine precisely the types of organisms which were being dissolved. However, since the spiral organisms, as a rule, disappeared before phagocytosis had begun, it would seem that these forms are disposed of by lysis and the spore-formers and other gram-positive types by phagocytosis later.

The cultures of the peritoneal fluids of the 61 autopsied animals, including some injected with the washings of the peritoneal cavities of animals injected with the samples, yielded pure cultures of coliform organisms in 13, or 21 per cent. This group included the animals injected with the peritoneal washings. In 11, or 18 per cent, few organisms other than members of the coliform group were isolated. In 7, or 11 per cent, a fairly large number of spore-formers were found, and in 6, or 10 per cent, a number of staphylococci in addition to coliform organisms. These were all animals which died in about eighteen hours after the injections. In 4, or 7 per cent, a number of streptococci were seen in the cultures. Twelve, or 20 per cent, all of which survived or had been injected with samples containing no coliform organisms, yielded no coliform organisms on culture; and 9, or 15 per cent, all of which had survived, gave completely negative cultures.

Having established the importance of the coliform group in the development and course of perforation peritonitis, experiments were carried out to see if the introduction of pure cultures of members of this group into the peritoneal cavity would give rise to conditions in the

unsuccessful. On several occasions, however, mixed cultures of streptococci and coliform organisms were injected intraperitoneally into guinea pigs, and cultures of the peritoneal fluids of the 5 animals which died showed that the streptococci were very infrequent or had died out entirely, while the coliform organisms were abundant. Other organisms (staphylococci, diptheroids, spore-formers, etc.), of course, were common in the suspensions and in the peritoneal fluids of the animals which died shortly after the injections, but were rarely found in the later stages of the infection; if they exerted any effect on the course of the peritonitis, this must have been at the very beginning.

A second feature noted was the low death rate among animals injected with cecal samples from which no members of the coliform group could be isolated by the routine method. It is generally believed by bacteriologists that colon bacilli are constant parasites of the large intestines of all warm-blooded animals. Chapman and Lieb,[4] however, found that the numbers of *E. coli* in the intestines were in indirect proportion to the severity of the obscure intestinal conditions which they were studying, and that the presence of pathogenic staphylococci in the nose and throat and of pathogenic streptococci in the intestines inhibited the colon bacilli in the intestines. Therefore, they thought that the presence of many colon bacilli in the intestines was normal and that the staphylococci and streptococci play an important role in these conditions by their inhibitive action. In this work, as a general rule, members of the coliform group were so numerous in the samples that the routine method seldom failed to reveal a large preponderance of these organisms over all other types in the cultures isolated. But, at times, certain lots of guinea pigs were received, from which cultures of the suspensions showed few or no members of this group and even further searching failed to detect them. The dominant organisms in the samples seemed to be more or less constant in each lot; for example, the first lot yielded large numbers of *Pseudomonas aeruginosa*, an organism only occasionally found in the rest of the experiments; the second and third lots, staphylococci; the fourth, spore-formers; and the fifth, an orange diphtheroid. No explanation of this phenomenon has been sought, but it is an interesting and noteworthy observation that certain lots of guinea pigs have too few coliform organisms in their cecums to be detected by culture.

But the significance of this observation, from the point of view of the subject studied here, lay in the fact that few of the animals injected with samples in which coliform organisms were scarce died of the injections (10, or 33 per cent, of the 30 animals, as compared with 64 per cent of the 44 animals injected with samples in which coliform organisms were abundant). With six of the ten samples in these lots, none of the 12 animals died. From the 10 animals which did die of the injections of the other samples of this type, coliform organisms could usually

An attempt was made to classify the strains obtained, to see if there were any bases by which the pathogenic could be distinguished from the nonpathogenic members. The question of the pathogenicity of the coliform group has been the subject of much discussion, the general opinion being that they are seldom very active pathogens. It is well known that coliform organisms are the most common cause of ascending infections of the urinary tract. There are scattered case reports of meningitis and septicemia in newborn children caused by colon bacilli. The work of Theobald Smith[18] has established that "scours" in calves is due to pathogenic strains of *E. coli*. Smith and Little[18] found experimentally that strains from this source were definitely pathogenic for many species of animals. But throughout bacteriologic literature one finds the tacit assumption that very few strains of *E. coli* are pathogenic and that infections with this organism are rare.

The classification of the colon-aerogenes group on the basis of cultural characters has been subjected to much investigation, which is still in progress and far from being settled. At the present time it seems to be generally conceded that members of the group fluctuate about two modal types, which are designated as Escherichia and Aerobacter respectively. But there also occur many intermediate forms. Members of the genus Escherichia are often subdivided into the species communis, not fermenting sucrose, and communior, which does ferment this sugar. Members of the genus Aerobacter are identified by the production of acetylmethylcarbinol and the power to attack citrate. Members of the whole group which correspond in some characters to one genus and in others to the other are termed intermediates.

The subject of hemolysis in the coliform group and its relationship to pathogenicity and to cultural reactions has received much attention. Schmidt[17] could not correlate hemolysis with any other character. Dudgeon, Wordley, and Bawtree[7] found that if one colony in a urinary infection was hemolytic the rest were also, while fecal strains were about equally divided between hemolytic and nonhemolytic strains. The hemolytic strains slowly lost the power to dissolve blood cells on storage, but the nonhemolytic strains did not gain it. Herrold[8] also found that the hemolytic property was a constant character of the strains in which it was found, but he could not correlate it with any other property of the strains. Nickolls[14] found hemolytic strains from patients with ulcerative colitis to be more virulent for mice than hemolytic strains from normal individuals. Buchgraber and Hilko[5] found a definite, but not absolute, correlation between hemolysis and the fermentation of sucrose.

The various pure cultures which I have studied behaved much alike, whether they came from cecal contents or from peritoneal exudates, or from animals of the same or another species, when tested for pathogenicity. Of the 11 rabbit strains tested, 61 per cent were pathogenic for test guinea pigs; of the 6 human strains, 61 per cent; of the 17 strains

injected animals similar to those resulting from the introduction of the total cecal flora. During the course of the investigation, guinea pigs were frequently injected intraperitoneally with suspensions in physiologic saline solution of freshly isolated coliform organisms in order to test the pathogenicity of the strains. The death rate from the injections was rather high; thirty, or 70 per cent, of the forty-three strains tested killed the test guinea pigs. This may be due to the rather large dose employed. It was found experimentally that 2 c.c. of a suspension of an eighteen-hour agar slant in 10 c.c. of physiologic saline solution was the best rough estimate of pathogenicity. Whether the organisms came directly from the cecal contents or from the peritoneal fluid of an injected animal seemed to have little effect upon the mortality of the guinea pigs. The findings at autopsy and the smears of the peritoneal fluids of these animals resembled closely those of the animals injected with the total cecal contents.

The peritoneal cavities of some of the guinea pigs injected with the suspensions were washed with sterile saline solution and the washings injected intraperitoneally into normal guinea pigs. Of 4 guinea pigs injected with washings from animals dead of the original injections, 3 died, and the findings at autopsy were noteworthy because of the selection of the coliform organisms by this process. In one case streptococci, which were seen in the fluids of the first animals, died out and the peritoneal fluids of the second animals yielded an abundance of coliform organisms.

Another experiment was suggested by the observation that a few of the guinea pigs, when injected with the cecal samples, showed immediate, though temporary, signs of illness. Okada,[15] studying experimental perforation peritonitis in dogs, thought that histamine was one of the most important causative factors in this condition. To test the possibility of this having some bearing on the results found in this work, guinea pigs were injected, one with a filtrate of a cecal suspension, one with a suspension in the filtrate of a coliform organism, and one with a saline suspension of the same organism. The filtrate-injected animal survived; the other two died. This was considered indicative of the absence of a noncellular toxic substance in the filtrate.

Steinberg and Ecker[20] report the finding of a soluble substance from cultures of *E. coli* which was toxic for rabbits. One of the cultures used in the work reported here, when heat-killed and injected intravenously into rabbits, killed many of them with toxic symptoms. To test the possibility of such a toxic substance in the culture, rabbits were injected intravenously with filtrates of broth cultures and of saline suspensions of agar slant cultures and with unheated living cultures of this organism. The rabbits survived and showed no symptoms. It was, therefore, concluded that heating the culture formed some toxic substance not present in the filtrate or in the living culture.

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isolated from injected guinea pigs, 62 per cent were pathogenic. From this it can be seen that many strains of coliform organisms, picked at random from a group, are pathogenic for guinea pigs when injected intraperitoneally. There was little difference noted when the strains were divided by cultural reactions, since of the 18 *E. coli communior* and 21 *E. coli communis* strains tested, about 60 per cent of each were pathogenic. The Aerobacter and intermediate types were much less frequently pathogenic, but these types were also far less numerous. Of the 18 hemolytic strains tested, 10, or 56 per cent, were pathogenic as compared to 9, or 82 per cent, of the 11 nonhemolytic strains. Of the 60 sucrose-positive members of the *E. coli* group tested for hemolysis, 30, or 50 per cent, were hemolytic; while 12, or 22 per cent, of the 55 sucrose-negative members of this group were hemolytic. The intermediate group tested (15 strains) had 9, or 61 per cent, which were hemolytic. But this correlation is not definite enough for any relationship to be established.

The serologic relationships of the coliform group, and even of members of the same species in the group, are very confused. Mackie[10] and Dudgeon, Wordley, and Bawtree[7] found little or no cross agglutination between strains of the group. Herrold[8] and Dudgeon and Pulvertaft[6] found agglutinins and precipitins to be type specific for the hemolytic strains but not for the nonhemolytic strains. Meyer and Löwenberg[13] found that hemolytic strains fell into a serologically united group with cross agglutinations; the nonhemolytic strains were only agglutinated by homologous antisera, but some sera against nonhemolytic strains agglutinated some of the hemolytic group. Nickolls[14] found that strains of hemolytic *E. coli* from normal feces and from feces of patients with ulcerative colitis were heterogeneous with occasional cross agglutinations. Lovell[9] found little cross agglutination between strains and often only low titers against the homologous antisera. It would seem from the published work that within the species *E. coli* there are many serologic subtypes.

The two antisera used in these experiments were prepared by repeatedly injecting rabbits intravenously with strains isolated during the experiments. One strain was isolated from the peritoneal cavity of a guinea pig which had died from an injection of the cecal contents of a guinea pig; the other was isolated directly from the cecal contents of a rabbit. Both strains were of the *E. coli communior* type, hemolytic, and pathogenic for guinea pigs.

The majority (57 per cent) of the 131 strains of coliform organisms tested against these antisera were agglutinated by neither of the sera. Of the 51 strains isolated from guinea pigs, 27, or 53 per cent, were agglutinated by the guinea pig antiserum and 23, or 45 per cent, were agglutinated by neither antiserum. The guinea pig antiserum agglutinated 53, or 40 per cent, of all the strains tested and the rabbit anti-

serum only 29, or 22 per cent; and, as a general rule, the strains agglutinated by the rabbit antiserum were also agglutinated by the guinea pig antiserum. When the strains were divided by cultural reactions, 36, or 55 per cent, of the 64 *E. coli communior* strains (the type to which both of the immunization cultures belonged) were agglutinated by either or both of the antisera; while only 13, or 19 per cent, of the 68 *E. coli communis* strains were agglutinated and 9, or 56 per cent, of the 16 strains of other types tested. Of the 49 hemolytic strains tested, 35, or 71 per cent, were agglutinated; while only 14, or 25 per cent, of the 57 nonhemolytic strains were agglutinated. When the cultures were grouped by the individual sources from which they originated, it was seen that, even there, there was little agreement as to the serologic reactions of the strains.

CONCLUSIONS

Guinea pigs, rabbits, and white mice were inoculated with the total cecal contents of guinea pigs, rabbits, and human beings. Of the organisms of the cecum which may escape into the peritoneal cavity on perforation, the coliform group are those most likely to cause peritonitis. Members of this group were the only intestinal bacteria found to be consistently pathogenic. The samples of the cecal contents containing few or no coliform organisms rarely gave rise to peritonitis. A large proportion of strains of colon bacilli occurring in the intestines are potentially virulent. Pathogenic strains of the coliform group cannot be distinguished by cultural characters, hemolysis, agglutinations, or any combination of these characters from the nonpathogenic strains.

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TRAUMA AND APPENDICITIS

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DURING the past few years, there have appeared in the literature a number of articles under the heading "Traumatic Appendicitis." Some of the cases presented are rather convincing, but in the majority the evidence in favor of trauma's playing a part in the etiology is rather flimsy, to say the least. Several authors state that the majority of the medical profession consider traumatic appendicitis a definite entity. I could find nothing in the literature upon which they based such an assertion. Therefore, I sent questionnaires to 125 leading surgeons in all parts of the United States, with the hope of obtaining data which would be of value in determining their reaction upon the subject. Eighty-seven surgeons responded. A few did not wish to be quoted, and the answers of two were too vague to be of value. The names and opinions of eighty-one are outlined in Table I.

The men quoted operated upon more than 72,803 cases of acute appendicitis. All agree that trauma, as an etiologic factor in acute appendicitis, is rare. Thirty-one, or 37.27 per cent, feel that it is possible for trauma to cause appendicitis. Six, or 7.4 per cent, believe that a previously diseased appendix might be aggravated by trauma but that appendicitis could not be initiated by an injury. Only eleven, or 13.58 per cent, think that a strain can play any part in the etiology of appendicitis. Twenty-four, or 29.62 per cent, saw cases in which they believed trauma entered into the etiology.

Questionnaires were also sent to 100 hospitals in the various sections of our country. Thirty hospitals answered, and the results are tabulated in Table II. There were 49,604 cases of acute appendicitis reported, with a history of trauma in only eleven. In one a pin was found in the appendix, and another was a case of intussusception, without external violence. If these two are eliminated, the remaining nine cases would give a percentage of 0.0018 in which trauma was mentioned as an etiologic agent.

The term, traumatic appendicitis, as used in this paper, refers only to appendicitis caused by external violence or muscular strain.

In the earlier articles the authors spoke of traumatic aggravation of a pre-existing chronic appendicitis, and this was explained by direct injury to the appendix or its mesentery. The explanation given in the more recent literature is one of overdistention of the appendical lumen by cecal contents as the result of increased intra-abdominal pressure.

Received for publication, July 3, 1933.

TABLE 1

SURGEONS	DO YOU BELIEVE THAT TRAUMATIC APPENDICITIS IS A DEFINITE ENTITY?	CAN APPENDICITIS BE PRODUCED BY A STRAIN?	HAVE YOU EVER SEEN A CASE CAUSED BY TRAUMA?	NUMBER OF CASES OPERATED IN THE PAST TEN YEARS
Clark L. Abbott, Oakland, Calif.	I believe that it could be.	I believe that any condition of strain which produces internal colon pressure may be a causative factor.	No	Did not state
Irvin Abell, Jr., Louisville, Ky.	No	No	No	500
Robert J. Alexander, Salt Lake City, Utah	No	No	No	More than 900
Elmer R. Arn, Dayton, Ohio	No	No	No	3,516
W. Wayne Babcock, Philadelphia, Pa.	Possible by injury comparable to that leading to crush or rupture of the intestine.	No	Have seen a few cases where quiescent appendix has been lighted into activity by trauma.	2,000 or 3,000
Fred Bailey, St. Louis, Mo.	I do not believe a normal appendix could be sufficiently traumatized by a nonpenetrating injury to cause acute appendicitis.	No, unless under some unusual condition.	One. A case of subacute appendicitis directly traumatized and it progressed into gangrene and rupture.	Probably 300 or over
Fredric W. Bancroft, New York, N. Y.	Yes	No	No	Several hundred
Robert F. Barber, Brooklyn, N. Y.	No	No	No	Perhaps 2,000 to 3,000
Fenwick Beekman, New York, N. Y.	Might be possible for trauma to cause obstruction to the circulation, producing appendicitis. Must be rare.	No	No	200
Bertram Bernheim, Baltimore, Md.	No	No	No	Several hundred

R. Russell Best, Omaha, Neb.	Possible, but must be rare.	No	No		
Carl E. Black, Jacksonville, Ill.	Possible, but rare.				
John O. Bower, Philadelphia, Pa.	No	Strain would have to be severe enough to amount to trauma.	No		400
James A. Cahill, Jr., Washington, D. C.	No	No	No		About 250
V. E. Chesky, Halstead, Kan.	No	No	No		Did not state
Reynold Church, New York, N. Y.	No	No	No	I saw one case where an oil-field worker claimed to have been struck in the abdomen three days before. The appendix was ruptured when he entered our hospital.	About 3,500
W. A. Coventry, Duluth, Minn.	No	No	No	No	About 400
Wm. A. Cubbins, Chicago, Ill.	I think there is only one time to make a diagnosis of traumatic appendicitis, and that is when a perfectly well individual gives a history of having had a severe abdominal injury, is operated upon early, and a microscopic section shows an injury to tissues. This could not possibly be demonstrated after a lapse of twenty-four hours.	I have had only one case in my experience where there was any possibility of stating that a strain had anything to do with the production of an acute appendicitis.	No	A wrestler who ate a heavy meal at noon engaged in a heavy wrestling struggle at 4 o'clock and immediately afterward suffered severe pain, agonizing in type. He was operated upon about four hours later, and microscopic section showed he had apparently ruptured the inner lining of his appendix.	More than 500
					More than 500
					About 250

TABLE I—CONT'D

SURGEONS	DO YOU BELIEVE THAT TRAUMATIC APPENDICITIS IS A DEFINITE ENTITY?	CAN APPENDICITIS BE PRODUCED BY A STRAIN?	HAVE YOU EVER SEEN A CASE CAUSED BY TRAUMA?	NUMBER OF CASES OPERATED IN THE PAST TEN YEARS
George M. Curtis, Columbus, Ohio	Theoretically possible.	Theoretically possible.	No	323
Vernon C. David, Chicago, Ill.	No	No	No	Did not state
Edward B. Dewey, Pasadena, Calif.	Yes. Rare.	No	One. Result of jumping six feet to ground. Symptoms followed immediately. At operation, fecalith with obstruction and beginning gangrene was found.	Did not state
Arthur W. Elting, Albany, N. Y.	No	No	No	Did not state
W. L. Estes, Jr., Bethlehem, Pa.	No	No	Have seen one case of acute suppurative appendicitis, in which I thought trauma might have something to do with its etiology.	2,500
John M. T. Finney, Baltimore, Md.	Yes	Yes	Yes	2,000 conservative estimate
John M. T. Finney, Jr., Baltimore, Md.	Yes, but exceedingly rare.	It is conceivable that it could be caused by a strain.	Two. A child 6 years old fell from a porch (about five feet) and struck flat on abdomen. Operated upon within six hours. A very acute appendicitis was found. I also saw a case where a revolver bullet perforated the appendix.	About 2,000

Joseph H. Foles, New York, N. Y.	No	No	No	
Joseph H. Francis, Mem-phis, Tenn.	No	No	No	At least 500
Louis Frank, Louisville, Ky.	I think it is possible that blows on the abdomen might distend an appendix and so induce an inflammatory reaction.	I expect it could result from sudden increase of intra-abdominal pressure.	No	300 to 500
W. Edward Gallie, Toronto, Ont.	No	No	No	At least 500 or 600
Gatewood, Chicago, Ill.	Theoretically possible.	No	No	Few in last ten years, but several hundred before that.
Willis D. Gatch, Indianapolis, Ind.	Possible for a direct blow over an inflamed or an adherent appendix to cause trouble.	No	No	463
C. F. Hegner, Denver, Colo.	Per se, no. May be contributory in a previously diseased appendix.	No	No	Easily 1,000
Arthur E. Hertzler, Halstead, Kan.	No	No	No	120
Charles G. Heyd, New York, N. Y.	No	No	No	500 to 1,000
Wm. B. Holden, Portland, Ore.	If so very rare.	No	No	601
J. Shelton Horsley, Richmond, Va.	Yes	No	No	500 to 1,000
Arnold S. Jackson, Madison, Wis.	Possible	No	I do not recall a case in which the diagnosis was unquestionable. I have seen one questionable case.	My two sons and I have operated upon 900 in the last eight years. 1,200 appendectomies have been done in the Jackson Clinic.
		Possible		

TABLE I—CONT'D

SURGEONS	DO YOU BELIEVE THAT TRAUMATIC APPENDICITIS IS A DEFINITE ENTITY?	CAN APPENDICITIS BE PRODUCED BY A STRAIN?	HAVE YOU EVER SEEN A CASE CAUSED BY TRAUMA?	NUMBER OF CASES OPERATED IN THE PAST TEN YEARS
Thomas M. Joyce, Portland, Ore.	Yes	I am not sure it could be caused by a strain.	One case caused by a direct blow.	My associates and I have operated upon 1,900.
Frank H. Lahey, Boston, Mass.	No	No	No	Did not state
O. F. Lamson, Seattle, Wash.	Only by a direct blow over the region of the appendix.	No	One. A direct blow on the abdomen and the patient developed acute appendicitis within two or three days.	About 300
E. Martin Larson, Great Falls, Mont.	I do.	No	No	600 or 800
Edwin P. Lehman, University, Va.	I suppose it is pathologically possible that a direct contusion of the appendix might initiate appendicitis. In view of the frequency of the disease, I do not see how even a history of a blow on the abdomen could be proven as the cause of any case of appendicitis. In any event, it would be a rare occurrence.	No	No	Almost 1,500
LeRoy D. Long, Oklahoma City, Okla.	Only where there is direct trauma.	No	One. A horse stepped on a little boy's abdomen and there was a traumatic division of the appendix.	Approximately 500

J. M. Mason, Birmingham, Ala.	No	No	No	Several hundred
Michael L. Mason, Chicago, Ill.	No	No	No	About 250
Richard H. Miller, Boston, Mass.	No	No	No	Did not state
Charles F. Nassau, Philadelphia, Pa.	No	No	No	Did not state
John R. Nilsson, Omaha, Neb.	No	No	No	Several hundred
Milton Oehsner, New Orleans, La.	Trauma might cause an acute exacerbation in an appendix in which there is latent infection.	No	No	Approximately 2,000 to 3,000
Thomas G. Orr, Kansas City, Mo.	No	No	No	At least 600
Ashley W. Oughterson, New Haven, Conn.	Trauma may cause inflammation but rarely or almost never in the appendix.	No	No	100
Grover C. Pemberthy, Detroit, Mich.	No, except where trauma may aggravate a gangrenous appendix or cause an appendical abscess to rupture.	No	No	Estimated 800
Edward W. Peterson, New York, N. Y.	No	Possible but hardly probable.	One, and that doubtful.	Did not state
Damon B. Pfeiffer, Philadelphia, Pa.	No	No	No	Roughly 4,000 to 5,000

TABLE I—CONT'D

SURGEONS	DO YOU BELIEVE THAT TRAUMATIC APPENDICITIS IS A DEFINITE ENTITY?	CAN APPENDICITIS BE PRODUCED BY A STRAIN?	HAVE YOU EVER SEEN A CASE CAUSED BY TRAUMA?	NUMBER OF CASES OPERATED IN THE PAST TEN YEARS
I. S. Ravdin, Philadelphia, Pa.	Not in the sense in which it is commonly used, but I have seen contusion of the appendix.	No	Yes, traumatic amputation.	Almost 2,000
J. Sumter Rhame, Charleston, S. C.	No	No	No	800 to 1,000
Mont R. Reid, Cincinnati, Ohio	On a few occasions it has appeared to me that trauma has initiated acute appendicitis.	Yes	Yes	2,000 by various members of the staff
Ralph T. Richards, Salt Lake City, Utah	No	No	No	2,013 by staff of Salt Lake Clinic
J. Stewart Rodman, Philadelphia, Pa.	I am not at all sure that there is such an entity as traumatic appendicitis.		It is my definite impression that I have seen over the years a very few cases following trauma in which that may have been a factor in the etiology. I am inclined to believe, however, it was coincidental rather than the actual cause.	Several hundred
Erwin R. Schmidt, Madison, Wis.	I believe it is possible.	No	One or two cases where it was difficult to say that it was not due to trauma.	1,303 by myself and associates since 1924
Carlo S. Scuderi, Chicago, Ill.	No	No	No	About 300

Linden Seed, Chicago, Ill.	No	No	No	No	Approximately 350
Charles F. Sherwin, St. Louis, Mo.	Yes, rarely.	Rarely	No	No	Probably 60 to 70
Arthur M. Shipley, Baltimore, Md.	I do not believe a blow on the abdominal wall is a predisposing factor in the development of appendicitis.	No	No	No	627 from 1930 to 1937
Albert O. Singleton, Galveston, Tex.	No	No	No	No	
Calvin M. Smyth, Jr., Philadelphia, Pa.	Only as an acute exacerbation of a previously damaged organ.	No	No	No	About 600
Samuel A. Thompson, New York, N. Y.	Possible, but very unlikely as a sole condition.	No	No	Yes, two cases in twenty-one years.	About 1,200
Clarence G. Toland, Los Angeles, Calif.	No	No	No	No	Approximately 1,200
Elmer D. Twyman, Kansas City, Mo.	Yes	No	No, not produced (unless pinched in a hernia, etc.) but precipitated; appendix not previously normal.	No	300
Fremont C. Vale, Detroit, Mich.	Yes, but very rarely.	No	No	Yes, in harvest laborers, wrestlers and a few accidents.	400
Frederick T. Van Beuren, Jr., New York, N. Y.	I doubt it.	I cannot see how it could be.	No	No	About 1,200
Arkell M. Vaughn, Chicago, Ill.	No	No	No	No	Approximately 2,500 including those done by my assistants.
				Possibly one.	Very few, retired from active work.
					Approximately 500

TABLE I—CONT'D

SURGEONS	DO YOU BELIEVE THAT TRAUMATIC APPENDICITIS IS A DEFINITE ENTITY?	CAN APPENDICITIS BE PRODUCED BY A STRAIN?	HAVE YOU EVER SEEN A CASE CAUSED BY TRAUMA?	NUMBER OF CASES OPERATED IN THE PAST TEN YEARS
Benjamin N. Wade, Portland, Ore.	Do not think so, although I have had one case that followed abdominal trauma.	No	No	678
Irving J. Walker, Boston, Mass.	No	No	No	Approximately 2,000
John B. Walker, New York, N. Y.	Doubtful	No	No	300
Owen H. Wangensteen, Minneapolis, Minn.	Trauma which severed or caused pendical vessels or caused obstruction to appendical lumen might cause it.	No	No	More than 1,000 in the University operated upon majority associates. by my associates.
J. Ogle Warfield, Jr., Washington, D. C.	No	Hard for me to conceive of any sort of a strain causing appendicitis.	No	Approximately 600
John M. Waugh, Mayo Clinic, Rochester, Minn.	Not convinced that it is a definite entity.			2,500 to 3,000 cases operated upon at the Mayo Clinic. In this series I am unaware of any patient with so-called traumatic appendicitis.
J. Calvin Weaver, Atlanta, Ga.	No	No	No	Probably 75 to 100
Samuel D. Weaver, Dallas, Tex.	Yes, but it is an extremely rare thing.	No	One. A young, thin-walled woman who was brutally kicked in the abdomen.	Approximately 800
Charles S. White, Washington, D. C.	No	No	No	1,500 to 2,000

Morehead has stated that it is highly improbable that any violence could produce a lesion of such a deep-seated, movable, well-protected, tiny piece of intestine, and yet do no damage to surrounding intestine near the source of violence and far more vulnerable. In answer to this, Ludington asserts that the deep location and the mobility of the appendix would, indeed, be safeguards against injury if the abdomen were a solid body and, in obedience to the laws of physics, transmitted a received force only in the direction in which the force was applied. But the abdomen is not a solid body; it is essentially a liquid and gaseous mass and is subject to the laws governing the transmission of force by liquids and gaseous mediums; i.e., the pressure exerted on it is transmitted equally in all directions. The deep location of the appendix, therefore, is not a factor that contributes either to the liability of the appendix to damage resulting from external violence, or to its immunity in such an accident.

If the contention of Ludington's that the force is transmitted equally in all directions is correct, then there would be as much pressure applied to the appendix as to the cecum, and the contents of the cecum could not be forced into the appendix.

As evidence that the contents can be forced into the appendix, numerous authors claim that, following a barium meal, the barium can be forced from the cecum into the appendix by light manual pressure. I asked the opinion of a number of roentgenologists regarding this procedure, and it was the consensus that rarely, if ever, could barium be forced into the appendix by manipulation of the cecum. F. B. Stephenson stated that he does not believe that he ever filled an appendix by manipulation of the cecum following a barium meal or barium enema. K. D. A. Allen said: "In fluoroscopy study of the colon, I find it very difficult indeed, to visualize the appendix by barium enema." L. D. Crosby said: "I have never been conscious of filling an appendix by manipulation following a barium meal, and I do not believe it possible; unless the opening into the lumen of the appendix is unusually large."

According to Spicer, increased intraintestinal pressure causes pressure hemorrhage at the antimesenteric surface of the intestine. McCarthy and Magrath claim that the blood supply to the appendix may be occluded by external trauma, causing appendicitis or gangrene. Wells, experimenting on rabbits, showed that ligation of the appendicular artery and vein did not produce any obvious change in the appendix. In like manner, ligation of the mesoappendix failed to produce any change in the appendix. However, ligation of the appendicular vessels and the mesoappendix was followed by gangrenous appendicitis and death occurred in three days.

In view of Wells' findings, it would seem to me that any injury severe enough to cause appendicitis, by interference with the blood

TABLE II*

HOSPITALS	ACUTE APPENDICITIS CASES OPERATED UPON	CASES GIVING HISTORY OF TRAUMA
Baptist Memorial, Memphis, Tenn.	4,868	None
Bellevue, New York, N. Y.	4,446	None
Cedars of Lebanon, Los Angeles, Calif.	1,026	One. Severe strain of abdominal and intercostal muscles.
City Hospital, Baltimore, Md.	1,037	None
Colorado General, Denver, Colo.	484	Two. Man aged 37 years, pitching horseshoes when suddenly seized with severe pain in the pit of his stomach. Pain subsided in a short time, but returned later and was followed by nausea and vomiting. At operation, an acute appendicitis was found, but no evidence of trauma. Second case was that of a man aged 27 years, who was pulling up turnips in a garden, when he developed a pain over the entire abdomen. The pain became more severe, and he was operated upon twelve hours later. At operation, an acute appendicitis was found, but no evidence of trauma.
Columbus, Seattle, Wash.	1,287	One
Corwin, Pueblo, Colo.	642	None
Fitzgerald-Mercy, Darby, Pa.	575	One
General, Fresno, Calif.	1,800	None
General, Kansas City, Mo.	1,084	None
Grace, Detroit, Mich.	4,270	One
Graduate, University of Pennsylvania, Philadelphia, Pa.	1,122	None
Indianapolis City, Indianapolis, Ind.	1,981	None
Johns Hopkins, Baltimore, Md.	1,000	One
Mercy, Pittsburgh, Pa.	3,963	None
New York, New York, N. Y.	1,960	None

*All cases were operated upon between 1929 and 1938 with the following exceptions: Cedars of Lebanon, 1930-1938; Fitzgerald-Mercy, 1933-1938; St. Lukes, San Francisco, 1934-1938; San Francisco Hospital, 1927-1937; University Hospital, San Francisco, 1928-1937.

TABLE II—CONT'D

HOSPITALS	ACUTE APPENDICITIS CASES OPERATED UPON	CASES GIVING HISTORY OF TRAUMA
Passavant, Chicago, Ill.	900	None
Peter Bent Brigham, Boston, Mass.	866	None
St. Luke's, Kansas City, Mo.	750	None
St. Vincent's, Portland, Ore.	1,222	None
San Bernardino Charity, San Bernardino, Calif.	1,709	Two. In one a pin was found in the appendix. The other was struck in the abdomen with a sling.
Temple University, Philadelphia, Pa.	Did not state	None
Union Memorial, Philadelphia, Pa.	1,970	None
University, Augusta, Ga.	1,357	None
University, Baltimore, Md.	2,418	None
University of Kansas, Kansas City, Kan.	More than 600	None
University of California, San Francisco, Calif.	468	One. Intussusception.
Western Pennsylvania, Pittsburgh, Pa.	2,624	One. A direct blow on the abdomen with hemorrhage.

supply of the appendix, would cause considerable damage to the cecum and surrounding intestine, as well as to the abdominal wall.

Robinson advances the theory that action of the psoas muscle may act as a mechanical factor in producing appendicitis in those cases in which the organ lies on the muscle. Powerful contractions of the muscle irritate the appendix, causing adhesions, bands, angulations, kinks, and obstruction. If such were the case, a large number of individuals with retrocecal appendices would have developed appendicitis in childhood following such exercise as bicycling.

Wangensteen said: "Whereas there may be other causes of appendicitis than obstruction, the only *tangible cause* is obstruction, and it would appear that this cause alone will suffice to account for all the varieties observed clinically. Fecaliths and swelling of lymphoid tissue are probably the most frequent causes of appendical obstruction in *man*."

If trauma plays any part in acute appendicitis, it is certainly rare. I cannot accept the theory that trauma forces cecal contents into the appendix or forces fecaliths farther into the appendical lumen. If this were a fact, then we should see a lot more cases of acute appendicitis following the large number of automobile accidents seen today. I can conceive of an appendix being traumatized by a direct blow,

if it lay over the brim of the pelvis; or it could possibly be bruised, if it were close to the anterior abdominal wall in an extremely thin individual, but I believe that in such instances there would be other evidence of trauma.

Kessler asserts that laborers, who exert a great deal of back and abdominal strain, manifest very little, if any, appendicitis. I think this contention will be corroborated by the majority of surgeons doing industrial work.

Fowler says that genuine traumatic pathology is rarely demonstrated in the appendix, when compared with the frequency with which contusion, hematoma, laceration and rupture or perforation are encountered in other abdominal organs.

As White states, it is a well-known fact that people are prone to establish a connection between any disability and an accident which may furnish a possible cause for it, and this is especially true if the question of compensation or liability enters into it.

Ludington and Fowler believe that the most important and reliable information bearing on the question of trauma as the causative factor of an appendicitis is obtained at operation. Rhodes said, "Whatever the mechanism of the production of appendicitis, the inflamed edematous viscus, covered with fibrin and filled with pus or perhaps gangrenous, will tell little of the story of its initiating pathology. Free blood in the peritoneal cavity or histological evidence of trauma are requisite findings."

Several authors, among whom are Fowler and Kessler, have enumerated features which they personally believed necessary to evaluate the part played by trauma in the etiology of appendicitis. Because of the importance of this subject from a medicolegal aspect, I should like to see the Council on Industrial Health of the American Medical Association establish some criteria which would guide us in determining whether or not trauma should be considered as an etiologic factor in a given case of appendicitis.

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FEVER THERAPY IN THE TREATMENT OF MECHANICAL INTESTINAL OBSTRUCTION DUE TO PELVIC INFLAMMATORY DISEASE

Report of Two Cases

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MECHANICAL intestinal obstruction due to pelvic inflammatory disease is not a frequent occurrence. Levine and Bliniek,[1] in their study of the subject, found but few references in the literature pertaining to intestinal obstruction secondary to inflammatory disease in the pelvis. They reported 3 cases and mentioned 36 cases found in the literature; however, no distinction was made as to the etiology of the adnexitis. Two of their cases were of gonococcal origin and one was postabortal. Thaler[2] described 3 cases of apparently specific pelvic inflammatory disease complicated by mechanical intestinal obstruction; Kaufman[3] reported 1 case; Périn,[4] 1 case; Martens,[5] 1 case; and Holtz,[6] 1 case.

In 7 of the above 9 cases, the obstruction was caused by agglutination of one or more loops of intestine to the inflammatory mass; the remaining 2 obstructions were due to adhesive bands. Flesch-Thebesius[7] reported 15 cases of obstruction secondary to pelvic inflammatory disease, but he did not state the type. He believed that most of these obstructions were caused by the string type of adhesion but that multiple adhesions were the cause in several. Turunen[8] reported 12 cases of obstruction due to adnexitis and stated that many were postabortal; in only 2 cases was the bowel closely adherent to the inflammatory mass.

Turunen explains the low incidence of mechanical intestinal obstruction as a complication of pelvic inflammatory disease upon the fact that the sigmoid colon, lying in juxtaposition with the inflammatory process, becomes adherent and prevents contact with the small bowel. Diarrhea frequently results, but seldom does obstruction occur. Levine and Bliniek state, as does Turunen, that intestinal obstruction is usually a complication of chronic or subsiding infection, yet in 10 of the 39 above-mentioned cases the process was acute. According to Levine and Bliniek, the mechanism of obstruction is usually kinking of an intestinal loop by retraction of the pelvic mass attending evacuation or healing of this mass.

It had been noted by many clinicians that gonorrheal infections were benefited by intercurrent infection in which there was a rather marked elevation of body temperature for an appreciable period of time. The treatment of gonococcal pelvic inflammatory disease by means of hyper-

Received for publication, June 23, 1939.

thermia has been extensively developed since the work of Carpenter, Boak, Mussi, and Warren[9] on the thermal death time of cultured gonococci.

In 1932 Warren and Wilson[10] reported the treatment of 9 cases of pelvic masses associated with gonococcal infection by means of general artificial fever brought about by mechanical means. Since that time many writers have included cases of pelvic cellulitis in their reports of gonorrheal infections treated by hyperthermia. All have been highly successful. Simpson[11] stated that the combination of Elliott treatment with the fever therapy lessened the required number of treatments; and Krusen, Randall, and Stuhler[12] advised the simultaneous administration of general artificial fever and either pelvic diathermy or Elliott treatment, because higher pelvic temperatures were obtained and the percentage of remissions was greater.

Bierman and Horowitz[13] reported that, following systemic fever therapy combined with pelvic diathermy, pelvic masses due to gonococcal infection begin to decrease in size from the seventh to the tenth day after treatment; pain usually disappears during the treatment. About two weeks after the treatment, the masses become very much smaller. Five of their 18 cases showed some residual enlargement of the adnexa two months after fever therapy. However, the adnexa were much smaller, and the mobility of the uterus was much greater in these cases.

In a recent review[14] of the 190 cases of mechanical obstruction of the small intestine seen in this clinic during the past seven years, it was noted that fever therapy was administered to two patients whose obstructions were caused by gonorrheal pelvic inflammatory disease. These patients were both seen during the past year.

CASE REPORTS

CASE 1.—V. H. (663530), a married white female, aged 37 years, was referred to the outpatient department Nov. 8, 1937, with a diagnosis of "emaciation and abdominal pain following surgical treatment for intestinal obstruction, peritonitis, and left tubal abscess 11 weeks ago." The patient complained of severe, sharp pain in the abdomen and vomiting; neither had been present for several days before coming to the University Hospitals.

She gave a history of uterine polypectomy in 1931 and again in 1934. She had gonorrhea with pelvic infection in 1933; this was treated and said to be cured. She also had an appendectomy in 1933. There was an acute exacerbation of the pelvic inflammatory disease in 1936. This was again treated and said to be cured. She had had no pregnancies.

She had had no symptoms or complaints for six months when in August, 1937, she suddenly developed crampy, colicky abdominal pain associated with nausea, vomiting, and distention. She was operated upon in another hospital twenty four hours later for intestinal obstruction. At this time, a left tubal abscess was removed. There was considerable abdominal distention postoperatively, and there was continuous drainage from the lower end of the low midline incision. The patient was discharged after forty days of hospitalization with the sinus still draining foul pus; she had constant diarrhea. She remained bloated and had several

short attacks of abdominal cramps associated with vomiting. The last of these had occurred several days before coming to this clinic.

Physical examination revealed a white woman of the stated age in a state of fair nutrition, weighing 126 pounds. No abnormal findings were present except in the abdomen and pelvis. There was a healed McBurney scar and a lower abdominal midline scar, from the lower end of which foul pus was draining. Introitus was nulliparous and would not admit two fingers. Examination of Bartholin's and Skene's glands was negative. There was moderate vaginitis and the cervix was nulliparous. The cervix pointed downward and backward. The uterus and adnexa were bound down and immovable. Cervical and urethral smears were negative for gonococci. Diagnosis was chronic pelvic inflammatory disease. She was given eight Elliott treatments and a course of sulfanilamide without appreciable improvement and was sent home for a rest period.

She returned Jan. 18, 1938, acutely ill, with a twenty-four-hour history of severe crampy abdominal pain, nausea, and vomiting. She had vomited six or seven times. The emesis was normal gastric contents. Examination revealed a well-developed and nourished white female of stated age, acutely ill, and moderately dehydrated; temperature, 99.6° F.; pulse, 96; respiration, 20; and blood pressure, 140 mm. systolic and 100 mm. diastolic. Examination of the head, neck, chest, and extremities was essentially negative. The abdomen was 2+ distended and a suggestion of visible peristalsis was present. The sinus at the lower end of the old midline scar was draining foul pus. There was generalized abdominal tenderness, maximum in the right lower quadrant where rebound tenderness was present; no masses were palpable. Borborygmi were heard at the acme of pain. The pelvic viscera were fixed by cellulitis. Hemoglobin was 72 per cent; white blood cells, 10,400 per c.mm. of blood; 76 per cent of these cells were polymorphonuclears, and 24 per cent were lymphocytes. The urine was negative. Blood nonprotein nitrogen was 38.7 mg. per cent, chlorides were 596 mg. per cent, and the carbon dioxide combining power was 56 volumes per cent. Scout films of the abdomen showed small bowel obstruction with very marked gaseous distention of some small bowel loops.

Diagnosis was mechanical obstruction of the small intestine, but colonic obstruction could not definitely be excluded so exploration was done the evening of admission. The abdomen was opened through a midleft rectus incision; no free fluid was present. The small intestine was dilated and had an abnormally thick wall. The omentum was adherent to the contents of the pelvis, and no further exploration was deemed advisable. Wangensteen's modification[15] of the Witzel type of enterostomy was done and intraluminal pressure, as determined through the enterostomy catheter, was 14 to 18 cm. of water, varying with respiration.

Surgery was well tolerated. Duodenal suction was instituted preoperatively and was continued for five days after operation. Suction was applied to the enterostomy catheter; drainage was profuse for the first week but diminished thereafter. Clamping of the enterostomy catheter was tolerated, and it was removed on the fifteenth day after operation. Cervical and urethral cultures were negative for gonococci Feb. 1, 1938, and cultures taken from the old midline sinus Feb. 2, 1938, were sterile. The patient tolerated a soft diet satisfactorily until the twenty-second postoperative day when abdominal cramps and vomiting recurred. Duodenal suction was again instituted, and a radiogram the next day showed markedly distended loops of small intestine. Suction was discontinued after seven days but was started the following day because of cramps, vomiting, and distention. Elliott treatments and hot sitz baths were begun at this point. During the next ten days suction was discontinued for only two days. The patient had been given transfusions and intravenous fluids during the periods of suction. Blood chlorides and serum proteins were normal, and the patient's weight was 120 pounds. The sinus had closed.

Fever therapy was advised by Dr. O. H. Wangensteen and on Feb. 25, 1938, the thirty-ninth postoperative day, this was begun, using the Kettering hypertherm under the direction of Dr. M. M. Cook. The patient was submitted to a temperature of 100.5 to 101° F. rectally for two hours on Feb. 25, 1938. She tolerated this well. Suction was removed Feb. 27 and was not used again. On March 1, her temperature was maintained at 101.5 to 102° F. rectally for three hours. Other treatments were as follows: March 4, 103.5° F. for three hours; March 9, 103.5 to 105° F. for three and one-half hours; and March 14, 103 to 104° F. for three hours. Her weight on March 14 was 120 pounds. She was discharged March 18, 1938, the sixtieth hospital day, eating a low residue, high caloric diet and taking mineral oil daily. She was instructed to take daily hot douches.

The patient was seen April 20, 1938, and stated that she had been well except that she had had a bout of abdominal cramps the second day after discharge; these cramps lasted five to six hours and were relieved by bed rest and a hypodermic injection. The corpus uteri was in second degree retroversion and the adnexa were relatively free from induration. She was again seen Dec. 30, 1938; about ten days before this she had had a short bout of cramps similar to the attack shortly after discharge. Menstrual periods had been regular every three weeks for the first three months following discharge and had then become regular every four weeks. She noted bloating before each period and her last period had started four days after her recent abdominal cramps. For the last month she had been eating a high residue type of diet, not advised by a physician, to do away with bloating. Her weight was 165 pounds.

Physical examination was negative except for the abdomen and pelvis. There was herniation of the lower midline incision with bowel visible and palpable immediately below the skin. Introitus was nulliparous; the urethra was clean; Bartholin's and Skene's glands were negative; and the cervix was clean although there was a small transverse laceration of the os. The corpus uteri was normal in size and shape and was freely movable. The left adnexa was negative; on the right there was a slightly tender, irregular induration extending from the right cornu of the uterus to the right side of the cul-de-sac. Here the right ovary was palpable and slightly enlarged. Cervical and urethral spreads and cultures were negative for gonococci. Because of the incisional hernia and the history of low-grade, intermittent obstruction, hernioplasty and concomitant enterolysis were advised.

The patient was admitted Jan. 16, 1939, with findings as above with the exception that at this time a mass was palpable in the left adnexa. A long double lumen tube with a terminal balloon was passed to the region of the terminal ileum in the pelvis; beyond this it would not progress. The balloon was deflated and barium sulfate mixture was injected. The ileum at this point, approximately one and one-half feet from the ileocecal valve, was fixed in the pelvis, and the mucosa was tented out in two areas with a concavity about one inch in length between the two "tents." There was stasis in this region; there was also some stasis in the region of the midileum.

At operation, Jan. 19, 1939, the lower one-half of the small bowel was thickened, and the lumen was larger than normal; this was most marked in the region of the terminal ileum. Here the collapsed bowel measured approximately 5 cm. from mesenteric to antimesenteric border. There were a number of stringlike adhesions between the various loops, but the patient's principal difficulty lay in very dense adhesions in the cul-de-sac where a loop of ileum was adherent to the posterior surface of the uterus and to the posterior pelvic wall. Beyond this, the ileum appeared normal. The right tube was dilated and bound down in the cul-de-sac. The sigmoid was also attached behind the uterus. The right ovary was cystic, and the cysts were punctured. An enterolysis and salpingectomy were done. The denuded area of ileum was sutured over, and omentum was brought down

into the pelvis. The hernia was repaired. Microscopic examination of the right tube revealed chronic salpingitis with hydrosalpinx.

Convalescence was uneventful, and the patient was discharged Feb. 3, 1939, the sixteenth postoperative day. She was seen a month later and had had no symptoms of obstruction. She stated in June, 1939, that she felt bloated for two or three days two weeks before each menstrual period; however, she had no cramps, nausea, or constipation.

CASE 2.—G. C. (667531), a married white female, aged 24 years, was admitted to the gynecology service March 25, 1938. She complained of abdominal pain and irregular menses. On Jan. 10, 1938, she began a regular, normal five-day period; during February no menses appeared and the patient believed she was pregnant. However, March 6, 1938, menstrual flow began and continued, with clots present, intermittently for ten days. With the irregular flow, the patient had right lower quadrant pain and occasionally a sharp right shoulder strap pain which the patient attributed to pleurisy. Bleeding stopped, and the patient was free from pain for about one week. Pain and intermittent bleeding recurred March 21, 1938, and the pain became severe March 23. Pain on defecation and urination was present.

Past history revealed that the patient had had an appendectomy for chronic appendicitis three years before and had had a salpingectomy for left tubal pregnancy two and one-half years before. She had been married twice; in February, 1938, primary syphilis was found in the patient and her husband and treatment was begun.

Physical examination revealed a chronically ill, thin woman who appeared somewhat older than her age. Temperature was 99.2° F.; pulse, 104; respirations, 20. Pupils were normal. There were no mucous membrane lesions, and no skin lesions of note. There was slight distention of the abdomen and healed right lower quadrant and midline suprapubic scars were present. There was tenderness and rebound tenderness over the lower abdomen, more marked on the left. Introitus was marital and mucopurulent discharge was present. There was a minimal cervical erosion; the corpus uteri was anterior and normal in size. Motion of the uterus was painful. There was a mass 4 by 4 by 6 cm. in the right adnexa with thickening and marked tenderness in the right adnexa; the left adnexa was similar, but the mass present on the left was smaller. Laboratory data of note were hemoglobin of 72 per cent, 13,400 leucocytes per c.mm. of blood, 93 per cent of which were neutrophiles. Urinalysis was normal except that numerous white blood cells were present. Cervical and urethral smears were negative for gonococci. Blood Wassermann was four plus positive. Diagnosis was acute exacerbation of chronic pelvic inflammatory disease with pelvic peritonitis, ectopic gestation to be excluded, and syphilis.

Treatment consisted of duodenal suction, parenteral fluids, hot packs to the abdomen, and sedation. However, the patient continued to have pain; and March 29, 1938, her temperature was 101.2° F. rectally and her abdomen was moderately distended. The pelvic induration was less, but the masses were the same. Scout films of the abdomen showed numerous dilated small bowel loops with little gas in the colon. The films were interpreted as mechanical small bowel obstruction by the roentgenologist. White blood count was 5,000 cells per c.mm. A cul-de-sac puncture was done, and 35 c.c. of sterile straw-colored fluid were removed. Rapid improvement began, and the patient was discharged April 6, afebrile, free from pain, and eating a full diet.

She was seen one week later in the outpatient department; she stated that she had had considerable pelvic pain with some nausea and vomiting but felt better. Pelvic examination was essentially unchanged.

On April 21, 1938, the patient had recurrence of abdominal pain, distention, and vomiting and was admitted to another hospital and transferred to the Uni-

versity Hospitals April 23 where she was again admitted to the gynecologic service. She stated that she had had gas pains and fecal vomiting. Temperature was 99.6° F. by mouth and the pulse was 100. The patient was dehydrated. The skin of the abdomen was pigmented from application of heat and the scars were again noted. There was moderate gaseous distention and moderate tenderness, but no rigidity. The abdomen was reported as silent. The hemoglobin was 87 per cent; there were 13,600 leucocytes per c.mm. of blood. Urinalysis was negative. Radiograph of the abdomen revealed marked gaseous distention of several loops of small bowel with gas present in the stomach and ascending colon. Diagnosis was subsiding pelvic inflammatory disease, low-grade intestinal obstruction, and syphilis. A note made later on the evening of admission reported the patient to be doubling up with cramps from time to time.

Conservative treatment was instituted, and the patient improved so that suction was discontinued April 28. An enema given that day was expelled with much flatus. The patient felt fine until May 3 when crampy pain, distention, and vomiting recurred. The abdomen was moderately distended, diffusely tender, and tympanitic. There was a questionable doughy mass in the right lower quadrant. Conservative treatment was again begun. The patient was seen by the surgical staff May 4, and a diagnosis of mechanical small bowel obstruction secondary to pelvic inflammatory disease was made. Scout films showed marked distention of the small bowel. Decompression was effected by means of a long double lumen tube. However, the patient could not tolerate clamping of the tube, and, after numerous attempts, fever therapy was begun on May 18.

The twenty-sixth hospital day, May 18, the first fever treatment, consisting of a temperature of 103 to 104.5° F. rectally for two hours, was given. This treatment was well tolerated. The patient's weight at that time was 84 pounds. Suction was discontinued May 20 after clamping of the catheter had been tolerated. The patient had occasional nausea and small emeses until June 4; however, neither cramps nor distention appeared. Other treatments were: May 23, 1938, 104° F. for three hours; May 26, 104° F. for three hours; June 1, 103° F. for three hours; June 7, 104° F. for three hours; and June 10, 104° F. for three hours. During the course of fever therapy, the patient's weight had dropped to 70 pounds, but it had risen to 78 pounds at the conclusion of treatment.

She was discharged June 14, 1938, ambulatory and feeling well. Examination of the pelvis revealed the corpus to be normal in shape, fairly movable, and in first degree retroversion; the right ovary was prolapsed and was moderately adherent to the lateral surface of the corpus; there was some thickening of the left adnexa. The gynecologic opinion was that there had been marked resolution of the pelvic inflammatory disease.

The patient was instructed to eat a low residue diet and take mineral oil, and when seen in the outpatient department Aug. 26, 1938, she was free of symptoms. In a follow-up letter received in December, 1938, she stated she had had a few slight abdominal pains and occasional lower abdominal ache, but had not been confined to bed; she had had no leucorrhea.

DISCUSSION

The hyperpyrexia regime of necessity must be particularly carefully supervised in these patients. The patient is weighed immediately before and the day after each treatment. Therapy is delayed until a positive or stationary weight balance is maintained if possible. If the patient is unable to stand, she is weighed upon a litter. An enema, if necessary, and sedation are given the evening before therapy. Breakfast

is omitted, and, if suction is being employed, paraoral fluids are given. Morphine in appropriate dosage is used for sedation; no morphine is used between treatments unless absolutely necessary. Fluids, administered intravenously or subcutaneously, are given at the termination of fever.

The importance of dehydration, chloride depletion, and alkalosis in artificial fever has been pointed out by Warren[16] and others. In the presence of intestinal obstruction, these factors are more readily thrown out of balance. The chloride content of the blood is checked frequently and any deficiency is corrected by the parenteral administration of physiologic saline solution. The carbon dioxide combining power of the blood is determined upon admission and subsequently as indicated. If the chloride content is normal, there should not be alkalosis. The state of hydration is followed by observation of the urine output (a urine output of 600 to 1,000 c.c. per twenty-four hours being maintained by liberal paraoral administration of fluid) and by determination of the specific gravity of the blood serum. While suction is being employed or the diet is restricted, the plasma proteins are determined from time to time, and, if they are low, transfusions are given. A "wet" chamber is used to produce and maintain fever; Gibson, Kopp, and Evans[17] showed fluid and chloride losses by perspiration are less and hyperventilation is less marked than when a "dry" chamber is used.

In all likelihood, with the resolution of the inflammation, mobility of the adherent intestinal loops is increased, edema is decreased, and intestinal obstruction due to traction and kinking is relieved. The string type of adhesion is probably affected but little, but since "strings" are rather long, decompression should allow release of the obstructing mechanism in most cases. From reported cases one obtains the impression that most mechanical intestinal obstruction in gonorrheal adnexitis is caused by agglutination of intestinal loops to the inflammatory mass; it is probable that this is true in most of the cases resistant to the usual conservative regime.

Hench, Slocumb, and Popp[18] state that the presumable clinical benefits of fever therapy are due to: (1) bacteriolytic or bacteriostatic action of heat; (2) increase in formation or mobilization of immune bodies; (3) local effect from vasodilation; and (4) general effect of heightened metabolism. While it has been generally considered that fever therapy is remarkably successful in gonorrhea because the gonococcus is killed by fever which is tolerated by man, prior to the work of Studdiford, Casper, and Seadron[19] the gonococcus was infrequently found in chronically inflamed adnexa. These authors obtained positive tubal cultures in 66 per cent of subacute and chronic cases and believe that organisms may remain for many years. One patient, whose tubal culture was positive, had salpingitis of at least ten years' duration, and another had had two eight-hour periods of artificial fever at 107° F.

Artificial fever has been used with variable success in a great many conditions where no specific action is present. It is quite possible that it would be of great aid in subacute pelvic peritonitis following appendical perforation. Diathermy has been employed here in one such instance, resulting in rapid localization and softening of the inflammatory process. The work being done upon the specific bacteriologic effects of ultrashort (Hertzian) waves in the future may open a new avenue of attack upon this problem.

SUMMARY

1. Two cases of mechanical small bowel obstruction, secondary to gonorrheal adnexitis, treated by hyperthermia are reported.

2. It is suggested that artificial fever may be of benefit in subacute pelvic peritonitis of nonspecific etiology.

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ANORECTAL COMPLICATIONS OF CHRONIC ULCERATIVE COLITIS, WITH SEVERAL ILLUSTRATIVE CASES

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ANORECTAL complications which accompany or follow chronic ulcerative colitis or thromboulcerative colitis are not infrequent, and the treatment of such complications requires the exercise of sound judgment if the accomplishment of more harm than good is to be prevented. Such complications, although in their basic features they resemble similar lesions which afflict otherwise healthy individuals, must be more carefully studied than usual; their relationship to the patient's immediate welfare and the possible result of surgical intervention must be considered seriously before any radical measures are instituted.

ANORECTAL ABSCESS AND FISTULA

The vulnerability of the crypts of Morgagni to infection is so well known that the occurrence of such complications as the ones to be described is not difficult to understand. In the study of 871 consecutive cases of chronic ulcerative colitis in which the patients were observed at the Mayo Clinic, it was learned that 73 patients, or 8.4 per cent of the entire group, had suffered development of anorectal abscesses or anorectal abscesses with subsequent fistulas. The frequency with which these lesions occurred was slightly greater among males (491 male patients, of whom 43, or 8.8 per cent, had an abscess or fistula) than it was among the females (380 female patients, of whom 30, or 7.9 per cent, had an abscess or fistula). Of 95 children under the age of 16 years in this group of 871 patients, 6, or 6.3 per cent, had suffered development of an abscess or fistula. This complication was found to rank third in order of frequency of occurrence, polyposis and stricture occurring more frequently in the order named. It is of interest, also, to observe that of the 3 patients whose condition terminated in death, there could be but little doubt that the formation of an acute anorectal abscess was the chief contributing factor in causing each fatality.

The anorectal abscesses and fistulas which complicate chronic ulcerative colitis manifest several peculiarities which are worthy of serious consideration and which probably explain, partially at least, several of the reasons these lesions deserve special study. Unlike the more common abscesses and fistulas occurring in the anorectal region of the body, these particular lesions do not seem to stimulate the formation of the usual firm, fibrous wall surrounding the abscess or fistula. Such a protective

Received for publication, June 26, 1939.

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SUMMARY

1. Two cases of mechanical small bowel obstruction, secondary to gonorrheal adnexitis, treated by hyperthermia are reported.

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Proctoscopic examination demonstrated chronic ulcerative colitis of activity 2 on the basis of 1 to 4. The lumen of the bowel was contracted about one-fourth. Roentgenologic studies of the colon disclosed that the entire colon was involved, with considerable narrowing and deformity.

On the ninth day after admission to the hospital, his temperature, which had varied from 98.6 to 99.8° F. (37 to 37.6° C.), increased to 103° F. (39.4° C.). At about the same time he complained of discomfort in the region of the right ischioanal fossa. The following day this region became tender, reddened, swollen, and indurated. Hot, moist packs were applied locally and general measures were instituted to relieve the pain.

On the sixth day following development of the abscess, definite fluctuation was noted. The external wall of the abscess was incised without anesthesia, and a stab wound was made into the cavity of the abscess. Several ounces of pus exuded. In spite of the fact that no attempt was made to enlarge the incision and the fact that it was felt that trauma had been limited to a minimum in providing drainage, the temperature of the patient increased promptly to 106° F. (41.1° C.) and evidence of severe toxemia persisted for the ensuing twenty-four hours, at which time the temperature returned to normal. Because of this patient's untoward reaction to a minimal surgical procedure, no attempt was made to repair the fistula.

CASE 2.—A woman, 28 years old, registered at the Mayo Clinic on March 17, 1938, because of an unhealed surgical wound that had followed an operation performed nine months previously for a fistula. For three years prior to coming to the Clinic she had had episodes of bloody diarrhea, with from six to fourteen passages of stools daily. Shortly after the onset of diarrhea, an abscess had developed on the left side of the anus; it had ruptured spontaneously and had continued to drain until the time of the fistulectomy.

On proctoscopic examination, the mucous membrane of the rectum appeared to be glazed, granular, and bled readily under trauma. Activity of the disease was graded 1 on the basis of 1 to 4. Posterior to, and extending into, the anal canal was a large, unhealed wound (4 cm. by 8 cm. in extent); the margins of this wound were smooth and its base was covered with abnormally excessive granulation tissue. In spite of the fact that nine months had elapsed from the time of the fistulectomy until the time she was seen at the Clinic, the wound showed little evidence of healing, even though the fistula apparently had been dealt with adequately. The discomfort caused by this wound had added immeasurably to the patient's disability.

STRICTURE

In the presence of chronic ulcerative colitis, the diameter of the anus appears to be altered differently among various patients. It will be discovered that the anus of some patients, when they are placed in the inverted position for sigmoidoscopic examination, appears to be patulous and of greater diameter than is normal. More frequently, however, anal contracture and actual formation of anorectal stricture will be disclosed by digital examination of the anus. The latter alteration is the result of one or more factors, such as irritation in the presence of infection, lack of the dilatation which is accomplished during the evacuation of a normal stool, and invasion of the anal and perianal tissues by infective bacteria, either of these tissues alone or in tissues contiguous to a similar invasion of the adjacent rectal wall.

The two factors mentioned first may cause a condition which, conservatively, might be called merely "anal contracture," but actual invasion

reaction appears to be minimal as it affects those patients whose chronic ulcerative colitis is most severe, and inversely, the reaction frequently is more marked among those patients whose colitis is mild. The primary or internal opening occurs as usual in the crypts of Morgagni, but it is often 0.5 to 1 cm. in diameter and the mucosal margin of such an opening, instead of being attached to the underlying tissues by scarring which results from the inflammatory process, appears as a loose, freely movable, irregular margin.

The destruction of tissue caused by the formation of the abscess often is extreme; especially is this true of the destruction of subcutaneous fat in those abscesses which invade portions beyond the perianal tissues. The abscesses occurring in the presence of chronic ulcerative colitis tend to vary from the more common type in their manner of progress; they will involve, frequently, several of the potential perianal spaces and almost as frequently progress simultaneously proximally and distally from the primary opening.

The incontinence of these patients is the frequent, ultimate result of tardily begun or inadequately completed natural protective measures, such as fibrosis and scarring. This result, while wholly undesirable, is often unavoidable because of the destruction of the involved portion of the external anal sphincter muscle or marked deformity of the anus, or a combination of both.

A patient afflicted with chronic ulcerative colitis and also suffering from anal incontinence is often relegated to the life of an invalid. It would seem, therefore, that if conservative measures can circumvent such a disaster they are extenuatingly justifiable. To the patient who has chronic ulcerative colitis, the presence of a fistula is a small price to pay if anal continence is thus insured.

ANAL INCONTINENCE

Anal incontinence afflicted 12 patients (1.4 per cent of the entire group), all of whom had been submitted to fistulectomies elsewhere. Some degree of anal incompetence is not uncommon among patients who become debilitated because of chronic ulcerative colitis. Undoubtedly, however, most patients would tolerate the inconvenience and discomfort of a fistula rather than sacrifice anal control as the price for the cure of the fistula.

The following abstracted reports of cases are presented to emphasize several of the unusual features of this disease: (1) the risk attendant upon any surgical manipulation; and (2) the unusual response of the involved tissues, causing remarkably prolonged convalescence and healing.

REPORT OF CASES

CASE 1.—A man, 26 years old, came to the Mayo Clinic in November, 1934, because of recurring episodes of bloody diarrhea, loss in weight, and abdominal cramps that had persisted for two years. Aside from the fact that he was emaciated and pale, the only significant observations were those referable to the large intestine.

Proctoscopic examination demonstrated chronic ulcerative colitis of activity 2 on the basis of 1 to 4. The lumen of the bowel was contracted about one-fourth. Roentgenologic studies of the colon disclosed that the entire colon was involved, with considerable narrowing and deformity.

On the ninth day after admission to the hospital, his temperature, which had varied from 98.6 to 99.8° F. (37 to 37.6° C.), increased to 103° F. (39.4° C.). At about the same time he complained of discomfort in the region of the right ischioanal fossa. The following day this region became tender, reddened, swollen, and indurated. Hot, moist packs were applied locally and general measures were instituted to relieve the pain.

On the sixth day following development of the abscess, definite fluctuation was noted. The external wall of the abscess was incised without anesthesia, and a stab wound was made into the cavity of the abscess. Several ounces of pus exuded. In spite of the fact that no attempt was made to enlarge the incision and the fact that it was felt that trauma had been limited to a minimum in providing drainage, the temperature of the patient increased promptly to 106° F. (41.1° C.) and evidence of severe toxemia persisted for the ensuing twenty-four hours, at which time the temperature returned to normal. Because of this patient's untoward reaction to a minimal surgical procedure, no attempt was made to repair the fistula.

CASE 2.—A woman, 28 years old, registered at the Mayo Clinic on March 17, 1938, because of an unhealed surgical wound that had followed an operation performed nine months previously for a fistula. For three years prior to coming to the Clinic she had had episodes of bloody diarrhea, with from six to fourteen passages of stools daily. Shortly after the onset of diarrhea, an abscess had developed on the left side of the anus; it had ruptured spontaneously and had continued to drain until the time of the fistulectomy.

On proctoscopic examination, the mucous membrane of the rectum appeared to be glazed, granular, and bled readily under trauma. Activity of the disease was graded 1 on the basis of 1 to 4. Posterior to, and extending into, the anal canal was a large, unhealed wound (4 cm. by 8 cm. in extent); the margins of this wound were smooth and its base was covered with abnormally excessive granulation tissue. In spite of the fact that nine months had elapsed from the time of the fistulectomy until the time she was seen at the Clinic, the wound showed little evidence of healing, even though the fistula apparently had been dealt with adequately. The discomfort caused by this wound had added immeasurably to the patient's disability.

STRICTURE

In the presence of chronic ulcerative colitis, the diameter of the anus appears to be altered differently among various patients. It will be discovered that the anus of some patients, when they are placed in the inverted position for sigmoidoscopic examination, appears to be patulous and of greater diameter than is normal. More frequently, however, anal contracture and actual formation of anorectal stricture will be disclosed by digital examination of the anus. The latter alteration is the result of one or more factors, such as irritation in the presence of infection, lack of the dilatation which is accomplished during the evacuation of a normal stool, and invasion of the anal and perianal tissues by infective bacteria, either of these tissues alone or in tissues contiguous to a similar invasion of the adjacent rectal wall.

The two factors mentioned first may cause a condition which, conservatively, might be called merely "anal contracture," but actual invasion

of the anal and perianal tissues by infective bacteria usually produces a real anal or anorectal stricture.

In the presence of chronic ulcerative colitis, stricture may occur in any portion of the rectum, sigmoid, or colon which is involved by the disease. Considering this fact and considering also the vulnerability of the dentate margin to injury and infection, it is surprising that anorectal strictures are not observed more frequently as accompaniments of this disease.

Anorectal stricture was observed 78 times (9 per cent) in the series of 871 cases studied. Anorectal stricture afflicted 43 (8.8 per cent) of 491 male patients and 36 (9.4 per cent) of 380 female patients.

As afflicting most of the patients, the stricture involved not only the anus but also the adjacent portion of the rectum. None of the patients observed required surgical treatment either locally or proximally, such as ileostomy, because of obstruction or other symptoms or effects.

ANAL ULCER

Twenty-seven (3.1 per cent) of the patients studied in this group had anal ulcers. This incidence is not great, but it does provide a problem of sufficient magnitude to justify special consideration. These ulcers are usually painful, cause pronounced anal spasm, and are not infrequently the site from which the constant secretion of serum and pus adds to the patient's discomfort, because of the cutaneous irritation thus initiated and aggravated. Some patients so afflicted will complain also of incontinence, which results from the gross deformity of the anus or from the patient's fear of contracting the sphincter sufficiently because of the pain such action would cause.

The ulcers vary considerably in size, conformation, location, and gross appearance. They may be solitary or multiple, isolated or confluent. Usually, their margins are rather ragged in appearance and overhang the base of the ulcer. The base of the ulcer frequently displays little evidence of normal healing processes; the ulcer appears to be irregular, not infrequently covered with a pseudomembrane, bleeds upon the slightest provocation, and on palpation little firmness, owing to fibrosis or scarring, can be detected. Granulation tissue, if present, may be excessive and also abnormally friable.

In such cases, it is advisable to treat anal ulcers palliatively, avoiding all surgical measures as much as possible. Cleansing of the part with warm solutions, such as witch hazel (Hamamelis), and applying nonirritating antiseptics, such as an aqueous solution of metaphen, usually will assist materially.

In addition to these measures, application of hot, wet packs to the anus and also one of the medicaments which in an ointment or water-soluble jelly will produce surface anesthesia, usually will alleviate some of the patient's discomfort. As a rule, however, such agents cannot be applied

with sufficient frequency to insure the patient's constant comfort. The amount of infection present and the patient's lowered resistance to infection would seem to preclude the injection of any anesthestic-bearing oily solution into the perianal tissues to overcome pain.

Oddly, when such ulcers as these have healed, the anus may contain, in addition to the deformity, strips of skin bridging the depressed scars, patently the result of the ulceration. These bridges of skin apparently result from the remnants of skin lining the anal canal under which the ulcers have burrowed. The subsequent healing of the base of such an ulcer as evidenced by the formation of granulation tissue and epithelization usually will cause the bridging remnant of skin to assume marked prominence, resulting in the unusual appearance mentioned.

ANAL FISSURE

Typical posterior or anterior anal fissures occurred among 24 patients (2.8 per cent) in the group of 871 studied. Fissures such as these are especially painful during the acute phase of chronic ulcerative colitis because of the trauma produced by the forceful expulsion of undigested food particles at defecation, but during the less active phase, when the stools are soft in consistency rather than liquid and are fewer in number, these fissures may cause little discomfort.

Surgical intervention performed in the attempt to eradicate the fissure seems inadvisable, especially when the primary disease is active. The topical application of such anesthesia-producing chemicals as metycaine, ethyl aminobenzoate, and similar agents and the application of heat locally by means of hot, wet packs usually will overcome severe discomfort. If surgical intervention is unavoidable, only minimal procedures should be attempted.

Superficial abrasions also frequently occur in the presence of chronic ulcerative colitis, and they deserve more serious consideration than do those observed in patients who are normal otherwise. Measures undertaken to insure local cleanliness, such as gentle bathing of the part with mild soap and water after each evacuation, assist materially in the prompt healing of such lesions as these.

HEMORRHOIDS

Hemorrhoids cannot be considered as complications of chronic ulcerative colitis in the same sense as the other lesions previously mentioned. Their presence, however, may add appreciably to the discomfort of the patient and may also increase the susceptibility of the anorectal tissues to infection. In our study of 871 cases, hemorrhoidal tissue was observed about as frequently as it would be in examining patients not afflicted with organic disease of the colon.

Thirty-two patients (3.7 per cent of the entire group of 871) stated that the symptoms of chronic ulcerative colitis were first noticed after

hemorrhoidectomies done elsewhere. Nearly all these patients consulted their physicians because of rectal bleeding. Following hemorrhoidectomy, not only did the symptoms of the colonic disease become more pronounced, but the resulting wounds healed very slowly.

Twenty-one patients, in addition to the 32 previously mentioned, had had a hemorrhoidectomy performed elsewhere after the symptoms of chronic ulcerative colitis had been observed for one or more years. Study of the cases represented by these patients emphasizes the need of sigmoidoscopic examination prior to the initiation of any rectal surgical treatment; such examination also will indicate the advisability of avoiding optional surgical procedures in the presence of chronic ulcerative colitis. The following abstracted history has been chosen because it illustrates the facts mentioned.

CASE 3.—In March, 1938, a man, 54 years old, registered at the Mayo Clinic because of uncontrollable diarrhea and bloody discharges of three years' duration. Two and one-half years prior to coming to the Clinic, he had consulted his physician because for a period of six months he had noticed the passage of blood after bowel movements. During that period he was having one formed stool a day. Hemorrhoidectomy was performed, the operation requiring him to remain in the hospital for three weeks. It required three months for the incision to heal. He continued to pass blood after healing was complete and began to pass from two to five stools daily, with blood. This condition had remained about the same until he was encountered at the Mayo Clinic. Proctoscopic examination demonstrated a scarred, contracted anal canal, above which the mucosa was slightly granular; it bled readily under slight trauma. The disease was active, 1 on the basis of 1 to 4. There was no contraction of the lumen of the bowel. Retrograde filling of the colon with opaque substance disclosed involvement of the left half of the colon.

SUMMARY AND CONCLUSIONS

1. Anal abscess or fistula is one of the most common complications of chronic ulcerative colitis. It afflicted 73 of 871 (8.4 per cent) consecutive patients whose records were studied. This condition ranked third among the complications, polyposis and stricture occurring more frequently, in the order named.

2. Indications for surgical interference in the treatment of anal conditions complicating or coexisting with chronic ulcerative colitis should be limited to emergencies, such as the formation of abscess.

3. Incision and drainage of abscesses should be carried out with a minimum of trauma.

4. The importance of careful proctoscopic examination is emphasized. Thirty-two patients (3.7 per cent) had a hemorrhoidectomy during the insidious initial stages of chronic ulcerative colitis. An additional 21 patients had an operation for hemorrhoids during the active course of the disease.

5. Stricture in the anorectal region occurred among 78 patients (9 per cent). For none of the patients was it necessary to do surgical intervention.

THE VASOCONSTRICTOR ACTION OF EPINEPHRINE ON THE DIGITAL ARTERIOLES OF MAN BEFORE AND AFTER SYMPATHECTOMY

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THE Meltzers'[28, 29] studies in 1903, the work of Elliott[11] in 1905, and subsequent investigations have shown conclusively that interruption of sympathetic nerves supplying smooth muscles of animals increases the contraction effect of epinephrine on the smooth muscles which have been denervated.[2, 3, 5, 7-12, 16, 18, 20, 26-29, 34, 40-43] Explanations of this physiologic phenomenon are theoretical and not pertinent to this presentation.[4, 8, 10, 31] Experimental studies on animals indicate that section of sympathetic nerve fibers distal to the sympathetic ganglia (postganglionic section) increases the contraction effect of epinephrine on smooth muscle more than section of sympathetic fibers proximal to the sympathetic ganglia (preganglionic section) does, although both procedures increase the sensitivity of smooth muscle to epinephrine.[3, 11, 16, 42] Ascroft's studies on the monkey indicated that postganglionic section increased the sensitivity of the smooth muscle of peripheral blood vessels to epinephrine about ten times; whereas, preganglionic section increased it only about three times.

It has been common observation that operation (lumbar ganglionectomy which is essentially preganglionic sympathectomy) for Raynaud's disease of the lower extremities uniformly results in cure; whereas, operation (cervicothoracic ganglionectomy, which is essentially postganglionic sympathectomy) for Raynaud's disease of the upper extremities produces less satisfactory results. Freeman, Smithwick, and White, by using a decrease in the temperature of the skin of the digits of man as a manifestation of sensitivity of arteriolar smooth muscle,[29] concluded that postganglionic denervation increased the sensitivity of the arterioles to epinephrine injected intravenously or liberated in the blood from the suprarenal glands as a result of hypoglycemia induced by injecting insulin.[15] Preganglionic section of sympathetic nerves seemed to increase the constrictor response of smooth muscle to epinephrine considerably less than did ganglionectomy.[6] Daniélopolu and his associates[9] had investigated this problem previously, by using the plethysmograph, and had found that after

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Received for publication, June 22, 1939.

left cervicothoracic ganglionectomy (postganglionic section) for epilepsy intravenous injection of epinephrine caused vasoconstriction of a greater degree in the skin of the left fingers than in the skin of the right fingers. Six years later[10] they reported that unilateral lumbar ganglionectomy (preganglionic section) performed on animals and on man caused intravenously injected epinephrine to provoke greater vasoconstriction in the denervated extremities than in the normally innervated extremities. In 1936, Smithwick[36] suggested an operation much the same as that described the year previously by Telford,[35] by means of which preganglionic sympathectomy of the upper extremities was performed, thus simulating, anatomically, sympathectomy for the lower extremities. Smithwick's operation was devised to prevent the greatly increased sensitivity of digital arterioles to epinephrine which he believed was a major cause for failures following ganglionectomy (postganglionic section) for Raynaud's disease of the hands.[1] His reports indicated that the results have supported his logic. The operation described by him has in his opinion prevented, for the most part, the failures which frequently followed ganglionectomy for Raynaud's disease of the hands.

In a previous report, two of us (Fatherree and Allen) stressed the shortcomings of the method of determining sensitivity of smooth muscle to intravenous injection of epinephrine by determining decreases in temperature of the skin. It was observed that there were marked differences in the response of the skin temperature of the different digits of the same extremities on different occasions and in the response of the temperature of the skin of the same digits on different occasions as a result of injecting a dilute solution of epinephrine into the blood of patients with normally innervated extremities. This observation tended to indicate that the method of study was unreliable because of marked differences in responses under apparently identical circumstances. However, subsequent studies indicated that the differences mentioned are much less after sympathectomy than they are before; therefore, the method of study seems more reliable when denervated extremities are being investigated than when normally innervated extremities are studied. Nevertheless, if reliable conclusions are to be made by this means of study, the results should be definite and consistent. Two of us (Fatherree and Allen) found also that the digital arterioles of patients with Raynaud's disease were not necessarily more sensitive to epinephrine than were the digital arterioles of patients who did not have Raynaud's disease. It was found that some patients with marked decreases in skin temperature following intravenous injection of epinephrine, which indicated marked sensitivity of arteriolar smooth muscle, did not have Raynaud's disease. We felt that our observations cast considerable doubt on the conclusions of other investigators that failure of ganglionectomy to

relieve Raynaud's disease of the hands was due to increased sensitivity of digital arterioles to epinephrine, which was induced by ganglionectomy.

The present report, which is concerned with a continuation of the study previously reported by two of us (Fatherree and Allen), deals with investigations carried out to determine the constrictor effect, determined by changes in skin temperature, of intravenous injection of epinephrine before and after sympathectomy. The method is essentially the same as that reported previously by two of us (Fatherree and Allen), who used the electric thermometer described by Sheard. Intra-arterial injections were performed after local anesthetization, and the same precautions of study were observed as when studies were conducted to determine sensitivity to intravenous injection of epinephrine. The degree of completeness of sympathectomy was determined by the sweating test described by Roth, which is based on the observation that, when complete sympathetic denervation has been performed, sweating cannot be induced reflexly. If sweating can be induced reflexly following operation, the sympathectomy is considered incomplete.

COMMENT ON THE SYMPATHETIC FIBERS CUT BY THE VARIOUS OPERATIONS

In the dog vasoconstrictor nerve fibers to the forepaw arise from the fourth to the tenth thoracic segments inclusive. Occasionally such fibers may arise from the third thoracic segment.[24] In the cat preganglionic fibers may also arise from the first thoracic segment to supply the forelimb.[22] Apparently in man the vasoconstrictor fibers of the hands arise from the second to the sixth or seventh thoracic segments respectively.[14] It is possible that some preganglionic fibers arise from the first thoracic nerve, but, if present, they are probably insignificant, since operations which do not disturb sympathetic nerves from the first thoracic segment may completely denervate the hand, a result indicated by absence of reflex sweating.[36, 38]

The important point, however, with regard to the question of whether the preganglionic or the postganglionic fibers, or both, are being cut by an operative procedure is the situation of the ganglia in which the synapses between the preganglionic and postganglionic fibers are made. Langley[24] stated that in the cat these synapses are in the stellate ganglion solely. In man it is more difficult to speak with certainty of the situation of the synaptic junctions of the sympathetic nerves which supply the upper extremity. However, it would appear likely that synapses are made in the middle cervical ganglion as well as the stellate ganglion, since the former ganglion usually is connected through gray rami with the fifth and sixth cervical nerves and, in some instances, also with the fourth and seventh cervical nerves.[21, 30] This probability is borne out by the finding of Foerster

left cervicothoracic ganglionectomy (postganglionic section) for epilepsy intravenous injection of epinephrine caused vasoconstriction of a greater degree in the skin of the left fingers than in the skin of the right fingers. Six years later[10] they reported that unilateral lumbar ganglionectomy (preganglionic section) performed on animals and on man caused intravenously injected epinephrine to provoke greater vasoconstriction in the denervated extremities than in the normally innervated extremities. In 1936, Smithwick[36] suggested an operation much the same as that described the year previously by Telford,[33] by means of which preganglionic sympathectomy of the upper extremities was performed, thus simulating, anatomically, sympathectomy for the lower extremities. Smithwick's operation was devised to prevent the greatly increased sensitivity of digital arterioles to epinephrine which he believed was a major cause for failures following ganglionectomy (postganglionic section) for Raynaud's disease of the hands.[1] His reports indicated that the results have supported his logic. The operation described by him has in his opinion prevented, for the most part, the failures which frequently followed ganglionectomy for Raynaud's disease of the hands.

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The hindlimb of the dog is supplied with vasomotor nerves by the eleventh thoracic to the second lumbar nerves inclusive and, to a less extent, by the third lumbar nerve, according to the investigation of Bradford and Bayliss, originally presented by Langley.[24] In man the vasomotor fibers appear to arise from the ninth thoracic to the third lumbar segments inclusive.[14] As in the upper extremities, however, the important point relative to whether preganglionic or postganglionic fibers are cut is the situation of the ganglia in which the synapses between the preganglionic and postganglionic fibers are made. In the cat the sympathetic nerve fibers to the hindleg make their synapses in the sixth and seventh lumbar and the first sacral ganglia, and a few perhaps in the second sacral ganglion.[24] In man it is probable, in the light of Langley's findings[23, 24] relative to the distribution of postganglionic fibers to the spinal nerves, that the synapses of the sympathetic nerve fibers to the feet are situated, for the most part, in the ganglia which correspond to the spinal nerves which form the sciatic nerve; namely, the fourth lumbar to the third sacral ganglia inclusive. When lumbar sympathectomy is performed, only preganglionic fibers are cut unless the fourth lumbar ganglion is removed, under which circumstance some postganglionic fibers may be excised.

In view of the definite and considerable difference in vasomotor reactions of the upper and lower extremities, as they concern both vasodilation and vasoconstriction,[2, 13, 19] it is probably not safe to compare vasoconstrictor effects of epinephrine in an upper extremity which has been sympathectomized by postganglionic section with vasoconstrictor effects in a lower extremity which has been sympathectomized by preganglionic section, and expect to draw reliable conclusions with regard to the relative constrictor effects of epinephrine on vessels which have been sympathectomized by postganglionic and preganglionic section respectively.

THE CONSTRICTOR EFFECT OF EPINEPHRINE ON DIGITAL VESSELS WHICH HAVE BEEN SYMPATHECTOMIZED BY SECTION OF A PERIPHERAL NERVE

We studied one patient who had undergone complete section of the median nerve at the wrist nine months previously. In the regions corresponding to the sensory distribution of the median nerve, tactile, pain, and thermal sensations were entirely lost and also motor power of the muscles of the hand supplied by this nerve was lost. There was no sweating in response to heating the entire body in the regions depicted in Fig. 1. Sweating was normal in the other hand. The vasoconstrictor effect of epinephrine was distinctly greater in the second finger, which was anesthetic and anhidrotic, than in the normally innervated fingers of the same hand and of the opposite hand. Dale and Richards, and Ascroft previously had noted increased vasoconstrictor effects of epinephrine in the feet of animals following section

that stimulation of the middle cervical ganglion produces vasoconstriction in the upper extremity of the corresponding side. It appears unlikely that the sympathetic fibers which supply the upper extremity of man make synapses in ganglia other than the middle cervical, the stellate, and the second thoracic.

In the treatment of vasospastic conditions of the upper extremity, currently two main types of operations are practiced; namely, the cervicothoracic ganglionectomy of Adson and the thoracic sympathectomy which was first reported by Telford,[38] and later by Smithwick[36] and still later by Telford again.[39] Cervicothoracic ganglionectomy consists essentially in removal of the stellate and second thoracic ganglia, with the intervening trunk. This operation, therefore, accomplished postganglionic section of all those sympathetic nerves, synapses of which are in either the stellate or second thoracic ganglia. However, the operation accomplishes preganglionic section of any sympathetic nerves to the upper extremity which pass upward through stellate or second thoracic ganglia to synapse in the middle cervical ganglion. Therefore, it would appear likely that cervicothoracic ganglionectomy accomplishes partially a postganglionic section and partially a preganglionic section of the sympathetic nerves which supply the upper extremity of man. It is probable, however, that postganglionic section is predominantly accomplished.

The thoracic type of sympathectomy, as recommended by Telford,[38, 39] consists in section of the thoracic sympathetic chain below the third thoracic ganglion and division of the rami which enter the sympathetic chain from the second and third thoracic nerves. Most likely, this operation accomplishes preganglionic section predominantly, since it is improbable that any considerable number of sympathetic fibers going to the upper extremity make their synapses in the second thoracic ganglion. The thoracic sympathectomy recommended by Smithwick[36] consists in section of the thoracic sympathetic trunk below the third thoracic ganglion, and section of both the anterior and posterior roots of the second and third intercostal nerves within the intervertebral foramina. Theoretically, this operation should result in section of preganglionic fibers exclusively, since the gray rami of the second thoracic ganglion are not cut as they may be in Telford's[38, 39] operation.

In presenting the results of our investigations concerning the effect of epinephrine on the digital arterioles of the upper extremities before and after sympathectomy, therefore, we shall consider that the digital vessels of persons who have undergone cervicothoracic ganglionectomy have been subjected to denervation (postganglionic section) and that the digital vessels of those who have undergone operation of the type recommended by Telford[38, 39] and by Smithwick[36] have been subjected to decentralization (preganglionic section).

of the peripheral nerves. However, we cannot find a report of this observation having been made previously on man.

THE CONSTRICTOR EFFECT OF EPINEPHRINE ON THE VESSELS SUPPLYING THE FINGERS, BEFORE AND AFTER CERVICOTHORACIC GANGLIONECTOMY (POSTGANGLIONIC SECTION)

We studied the vasoconstrictor effect of epinephrine, administered intravenously, on the digital vessels of five patients before and after cervicothoracic ganglionectomy performed according to the technique of Adson. Our results show that epinephrine produced greater vasoconstriction of the digital vessels of fingers after this type of sympathectomy than it did before the operation was performed (Fig. 2, and Table I). The average decrease in cutaneous temperature in all cases before operation was 1.6° C. and after operation it was 3.7° C. Thus, the magnitude of the decrease in cutaneous temperature after operation was twice that before operation. Sympathectomy appeared complete in all cases except Case 4, which was the only one in which sweating of hands could be induced. In this case mild sweating affected only the volar surfaces of the right third finger and of both wrists. From these studies it would appear that section of the postganglionic components of the sympathetic nerves to the blood vessels of the upper extremity of man does not produce nearly so great an increase in the sensitivity of the smooth muscle of the vessels to epinephrine as this procedure produces in monkeys.[3]

THE CONSTRICTOR EFFECT OF EPINEPHRINE ON THE VESSELS SUPPLYING THE FINGERS, BEFORE AND AFTER THORACIC SYMPATHECTOMY (PREGANGLIONIC SECTION)

Eight cases were studied, six by injecting epinephrine intravenously (Fig. 3 and Table II), and two by the intra-arterial injection of epinephrine. Sympathectomy appeared complete in all but Case 7, which was the only one in which sweating could be induced, and even in this case it could be induced only on the inner aspects of the right arm and forearm, the volar surface of the left forearm, and the left thenar eminence. In Case 6 (Table II) the procedure was bilateral section of the trunk below the third thoracic ganglion, bilateral resection of a proximal segment of the second and third intercostal nerves, and bilateral ramisectomy of the second thoracic ganglion. The procedure to which the patients in Cases 7 and 8 were subjected included bilateral section of the trunk below the third thoracic ganglion and bilateral ramisectomy of the second and third thoracic ganglia. In Case 9 the procedure included bilateral section of the thoracic trunk below the third thoracic ganglion, section of the rami of the second and third thoracic nerves on the right, and section of the second and third intercostal nerves on the left. In Case 10 the procedure included bilateral anterior rhizotomy of the

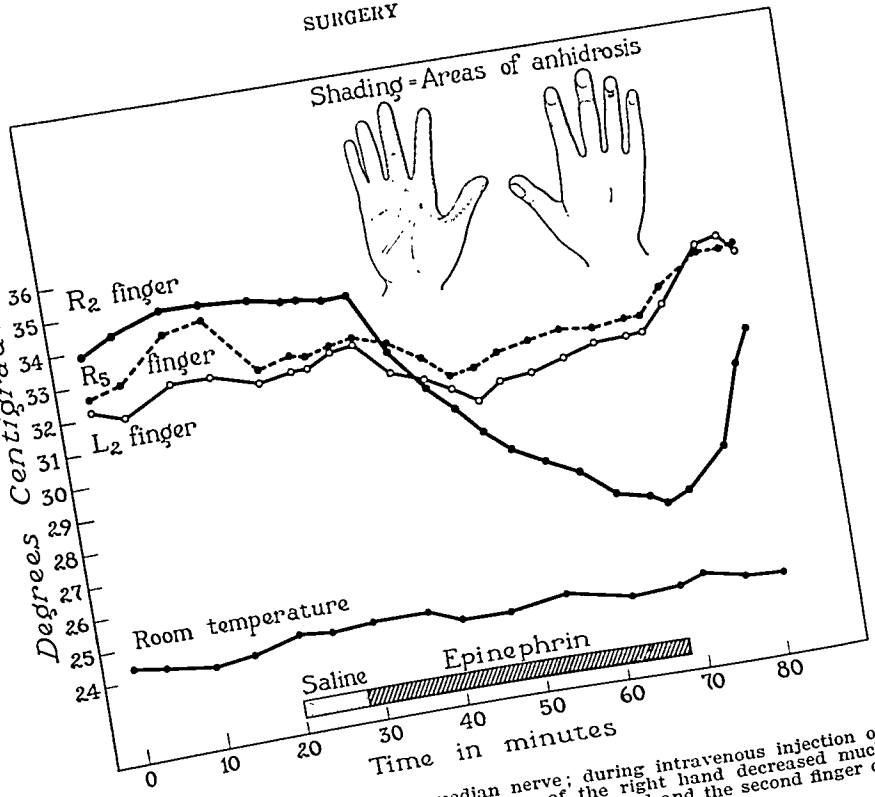


Fig. 1.—Traumatic section of right median nerve; during intravenous injection of epinephrine the temperature of the second finger of the right hand decreased much more than the temperature of the fifth finger of the right hand and the second finger of the left hand.

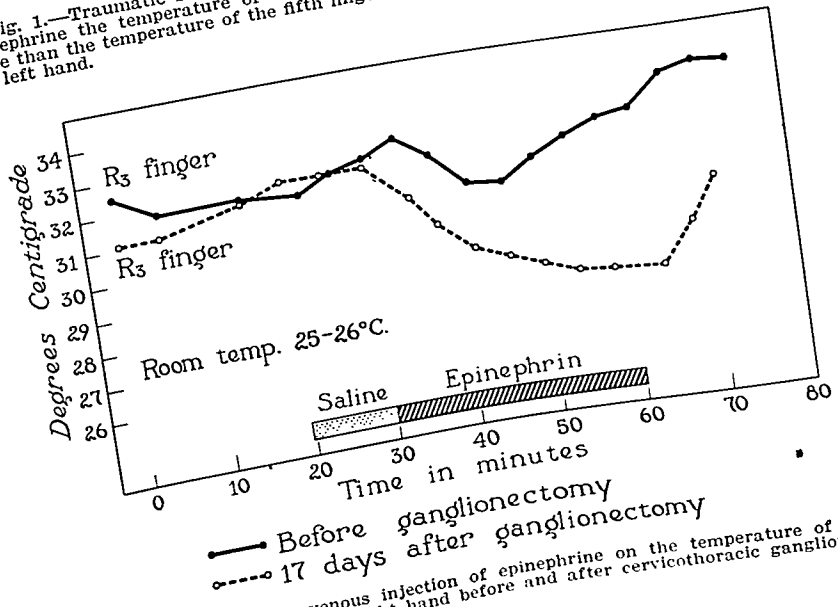


Fig. 2.—Effect of intravenous injection of epinephrine on the temperature of the skin of the third finger of the right hand before and after cervicothoracic ganglionectomy (postganglionic section).

second and third thoracic nerves, bilateral division of the trunk below the third thoracic ganglion, and bilateral section of the rami of the second and third thoracic nerves. Bilateral section of the rami of the second and third thoracic nerves was the procedure employed in Case 11. Hence, in all instances the section was predominantly or entirely preganglionic. In every instance in which epinephrine was injected intravenously, greater vasoconstriction was produced in the fingers after preganglionic section of the sympathetic fibers by thoracic sympathectomy than before the operation was performed. The average decrease in cutaneous temperatures before operation was 2.6° C. and after operation it was 4.6° C.

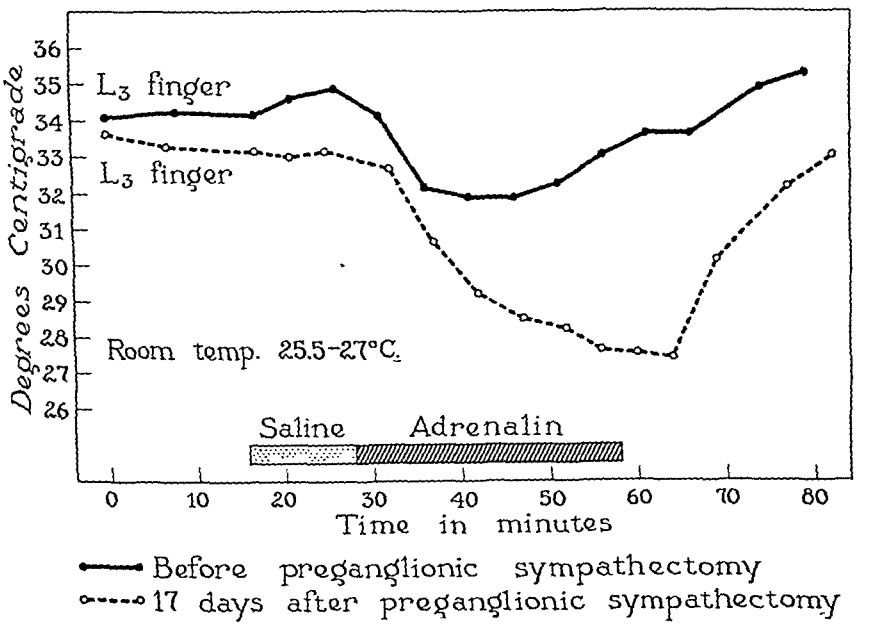


Fig. 3.—Effect of intravenous injection of epinephrine on the temperature of the skin of the third finger of the left hand before and after thoracic sympathectomy (preganglionic section).

Thus, the magnitude of the decrease in cutaneous temperature after operation was approximately twice that before operation. In the two cases in which epinephrine was injected intra-arterially, the operative procedures were similar; they included bilateral division of the main sympathetic trunk below the third thoracic ganglion and bilateral division of the rami of the second and third thoracic ganglia. In one of these two cases the vasoconstrictor effect was slightly greater and more persistent fourteen days after operation than it was before, and in the other case the vasoconstrictor effect was slightly greater before operation.

We have pointed out before that the method of study which we used was not an exact quantitative one. Although the vasoconstrictor effect produced by epinephrine, as indicated by the decrease in cutaneous

TABLE I

EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE TEMPERATURE OF THE SKIN OF THE FINGERS BEFORE AND AFTER CERVICOTHORACIC GANGLIONECTOMY (POSTGANGLIONIC SECTION)

CASE	DIAGNOSIS	BEFORE POSTGANGLIONIC SYMPATHECTOMY					AFTER POSTGANGLIONIC SYMPATHECTOMY					
		AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	DAYS FOLLOWING SYMPATHECTOMY
1	Raynaud's disease	33.1	1.8	5.0	15	26.0	31.0	3.9	4.4	32	25.0	41
2	Sclerodactylia	32.6	0.8	3.0	30	25.0	33.6	3.1	2.6	30	26.0	17
3	Raynaud's disease	33.2	2.5	2.7	26	24.3	32.5	3.0	2.5	26	25.0	13
4	Sclerodactylia	33.5	0.8	10.0	15	26.0	31.8	3.8	6.6	24	26.0	41
5	Causalgia	33.3	2.0	2.6	40	24.2	34.3	4.8	2.5	40	24.7	15

temperature, was increased by both operations, postganglionic section did not increase the magnitude of the vasomotor response to the intravenous injection of epinephrine more than preganglionic section did. We do not interpret these results as an indication that there is no difference in the magnitude of the vasoconstrictor effect of epinephrine following preganglionic and postganglionic section, but the results suggest that this is true. Certainly, if such a difference exists in man, it is small, much less obvious than it is in the monkey,[1] and probably of little clinical significance. Simmons and Sheehan recently have studied two patients who had undergone preganglionic section of the sympathetic nerves of one upper extremity and postganglionic section of the other upper extremity. They found that, when epinephrine was administered intravenously, the decrease in cutaneous temperature was greater on the side of the postganglionic section. They pointed out, however, that the difference was not very great.

THE CONSTRICTOR EFFECT OF EPINEPHRINE ON THE VESSELS SUPPLYING THE TOES, BEFORE AND AFTER LUMBAR SYMPATHECTOMY (PREGANGLIONIC SECTION)

Studies such as we are about to report have apparently not been made previously, although Daniélopolu and his associates[10] found that, after unilateral lumbar sympathectomy, sensitivity to intravenous injection of epinephrine was greater on the sympathectomized side than it was on the normally innervated side.

Four patients were subjected to lumbar ganglionectomy according to the technique of Adson (Table III). In all instances sympathectomy was complete. The average decrease in cutaneous temperature resulting from intravenously injected epinephrine was greater after operation than it was before in only two instances (Cases 12 and 13) and in one of these (Case 13) the change was insignificant.

The effects of intra-arterial injection of epinephrine were studied before and after operation in six cases. All but one of these (Case 1) were cases of hypertension. The operation consists of a ganglionic removal of the first and second lumbar ganglia with a division of the trunk between the second and third lumbar ganglia. The postoperative studies were carried out from twenty to fifty-one days following operation. In no instance could sweating of the feet or distal parts of the legs be demonstrated. In only two cases (Table IV, Cases 20 and 21) was the average decrease in temperature of the skin of the toes greater following operation than it was before, and in these cases the differences were not striking. However, in four of five cases persistence of the vasoconstrictor action was remarkably greater following operation than it was before (Table V). An example of this greater persistence of vasoconstrictor effect of epinephrine following sympathectomy is graphically presented in Fig. 4. These results are

TABLE II

EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE TEMPERATURE OF THE SKIN OF THE FINGERS BEFORE AND AFTER THORACIC SYMPATHECTOMY (PREGANGLIONIC SECTION)

CASE	DIAGNOSIS	BEFORE POSTGANGLIONIC SYMPATHECTOMY					AFTER POSTGANGLIONIC SYMPATHECTOMY					
		AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	DAYS FOLLOWING SYMPATHECTOMY
6	Raynaud's disease	33.6	2.9	2.7	30	24.6	32.9	4.9	2.7	30	25.0	14
7	Sclerodactylia	32.1	1.0	2.5	30	25.0	32.1	4.0	3.0	30	25.5	18
8	Sclerodactylia	34.3	3.1	4.2	34	27.0	32.3	5.2	3.3	33	25.5	17
9	Raynaud's disease	32.6	1.9	3.0	35	24.5	30.8	2.4	3.7	35	26.0	15
10	Raynaud's disease	33.2	2.3	2.8	35	25.1	34.1	5.4	.2.8	35	24.2	105
11	Raynaud's disease	32.9	4.7	2.5	30	25.0	33.0	6.0	2.5	30	24.8	16

in keeping with those which Elliott[11] obtained in experiments on animals. He found that all smooth muscle contracts with greater persistence in the presence of epinephrine following sympathectomy of preganglionic type.

The findings obtained from the observations just reported indicate that section of the preganglionic components of the sympathetic nerves which supply the toes results in no significant increase in sensitivity of the vessels when epinephrine is injected intravenously or intra-arterially.

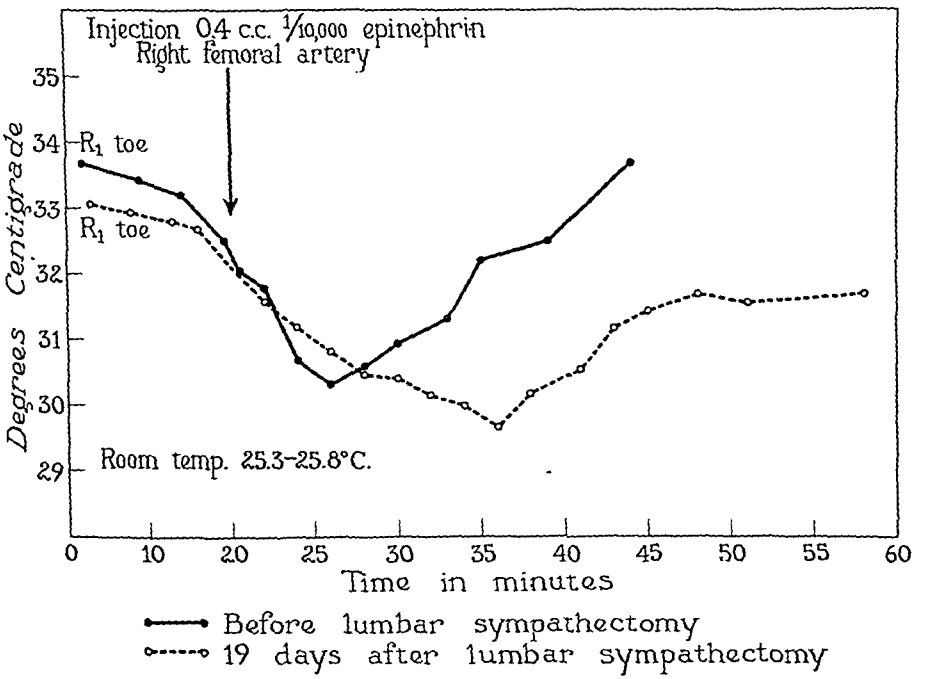


Fig. 4.—Effect of intra-arterial injection of epinephrine on the temperature of the first toe of the right foot before and after lumbar sympathectomy.

THE COMPARATIVE EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE CUTANEOUS TEMPERATURE OF TOES AND FINGERS DENERVATED OF SYMPATHETIC FIBERS

As stated previously, there has been advanced the hypothesis that failure of ganglionectomy (postganglionic section) to cure Raynaud's disease of the hands is due to the great sensitivity of arterioles which results from operation to normally circulating epinephrine, while routine cure of Raynaud's disease of the feet is due to the much less marked increase in sensitivity to epinephrine which results from lumbar sympathectomy (preganglionic section). If this is true, the temperature of the skin of the fingers of the patients who had undergone postganglionic section for Raynaud's disease of the hands ought to decrease much more than the cutaneous temperature of the toes

TABLE III

EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE TEMPERATURE OF THE SKIN OF THE TOES BEFORE AND AFTER LUMBAR GANGLIONECTOMY

CASE	DIAGNOSIS	BEFORE POSTGANGLIONIC SYMPATHECTOMY					AFTER POSTGANGLIONIC SYMPATHECTOMY					
		AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	AVERAGE SKIN TEMPERATURE BEFORE INJECTION OF EPINEPHRINE, DEGREES C.	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION OF EPINEPHRINE, DEGREES C.	RATE OF INJECTION OF EPINEPHRINE, C.C. PER MINUTE	TIME CONSUMED IN INJECTING EPINEPHRINE, MINUTES	ROOM TEMPERATURE, DEGREES C.	DAYS FOLLOWING SYMPATHECTOMY
12	Megalocolon	30.6	2.0	4.1	30	25.0	33.6	4.5	2.2	30	24.0	17
13	Raynaud's disease	31.5	3.5	2.7	30	24.6	32.9	3.9	2.7	30	24.7	36
14	Thromboangiitis obliterans	30.1	0.1	5.3	19	26.5	30.8	0.6*	2.3	31	27.0	9
15	Thromboangiitis obliterans	29.0	2.3	2.7	31	24.8	29.5	1.8	2.7	30	25.3	11

*This was not a decrease, but an increase, in cutaneous temperature.

in keeping with those which Elliott[11] obtained in experiments on animals. He found that all smooth muscle contracts with greater persistence in the presence of epinephrine following sympathectomy of preganglionic type.

The findings obtained from the observations just reported indicate that section of the preganglionic components of the sympathetic nerves which supply the toes results in no significant increase in sensitivity of the vessels when epinephrine is injected intravenously or intra-arterially.

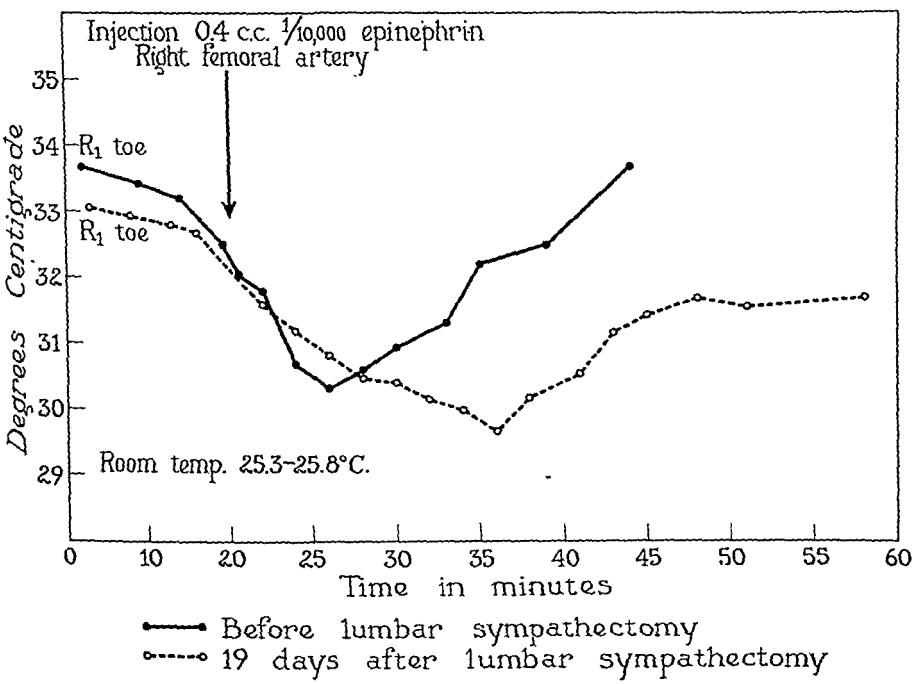


Fig. 4.—Effect of intra-arterial injection of epinephrine on the temperature of the first toe of the right foot before and after lumbar sympathectomy.

THE COMPARATIVE EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE CUTANEOUS TEMPERATURE OF TOES AND FINGERS DENERVATED OF SYMPATHETIC FIBERS

As stated previously, there has been advanced the hypothesis that failure of ganglionectomy (postganglionic section) to cure Raynaud's disease of the hands is due to the great sensitivity of arterioles which results from operation to normally circulating epinephrine, while routine cure of Raynaud's disease of the feet is due to the much less marked increase in sensitivity to epinephrine which results from lumbar sympathectomy (preganglionic section). If this is true, the temperature of the skin of the fingers of the patients who had undergone postganglionic section for Raynaud's disease of the hands ought to decrease much more than the cutaneous temperature of the toes

TABLE IV

EFFECT OF INTRA-ARTERIAL INJECTION OF EPINEPHRINE ON THE TEMPERATURE OF THE SKIN OF THE TOES BEFORE AND AFTER LUMBAR GANGLIONECTOMY

CASE	BEFORE SYMPATHECTOMY				FOLLOWING SYMPATHECTOMY			
	AMOUNT OF EPINEPHRINE INJECTED, C.C. OF 1:10,000 SOLUTION	AVERAGE SKIN TEMPERATURE AT TIME OF INJECTION	AVERAGE DECREASE IN SKIN TEMPERATURE AFTER INJECTION, DEGREES C.	ROOM TEMPERATURE, DEGREES C.	AMOUNT OF EPINEPHRINE INJECTED, C.C. OF 1:10,000 SOLUTION	AVERAGE SKIN TEMPERATURE AT TIME OF INJECTION	AVERAGE DECREASE IN SKIN TEMPERATURE, RESULT	ROOM TEMPERATURE, DEGREES C.
16	0.17	31.7	0.8	25.1	0.17	32.9	0.3	25.7
17	0.29	30.5	1.4	24.9	0.29	33.2	1.1	26.1
18	1.0	33.3	2.5	26.8	1.0	32.8	1.6	25.2
19	0.75	31.8	2.6	25.3	0.75	32.4	2.6	25.3
20	0.40	31.3	1.6	25.3	0.40	32.1	1.9	25.8
21	0.61	31.9	1.7	25.6	0.61	32.1	2.6	25.0

TABLE V

DURATION OF DECREASE IN TEMPERATURE OF THE SKIN OF THE TOES PRODUCED BY INTRA-ARTERIAL INJECTION OF EPINEPHRINE BEFORE AND AFTER LUMBAR GANGLIONECTOMY

CASE	AVERAGE DURATION OF DECREASE IN SKIN TEMPERATURE, MINUTES	
	BEFORE SYMPATHECTOMY	FOLLOWING SYMPATHECTOMY
22	10	24
23	11	24
24	22	27
25	14	22
26	24	10

following preganglionic section for Raynaud's disease of the feet, when epinephrine is injected intravenously. Two observations by Smithwick, Freeman, and White,[37] and White[41] indicate that this is true.

We injected epinephrine intravenously in three cases in which sympathectomy of all four extremities had been performed for Raynaud's disease (Table VI). In two of these cases (Cases 27 and 28) the upper extremities had been denervated by cervicothoracic ganglionectomy and the lower extremities had been denervated by lumbar ganglionectomy. In the third case the upper extremities had been denervated by preganglionic sympathectomy and the lower extremities by lumbar ganglionectomy (Table VI). Sweating tests indicated that lumbar sympathectomy was complete in all instances.

TABLE VI

EFFECT OF INTRAVENOUS INJECTION OF EPINEPHRINE ON THE TEMPERATURE OF THE SKIN OF THE HANDS AND FEET FOLLOWING SYMPATHECTOMY

CASE	ROOM TEMPERATURE, DEGREES C.	INJECTION OF EPINEPHRINE		AVERAGE SKIN TEMPERATURE BEFORE INJECTION, DEGREES C.		AVERAGE DECREASE IN CUTANEOUS TEMPERATURE, DEGREES C.		MONTHS AFTER OPERATION ON	
		RATE, C.C. PER MINUTE	TIME REQUIRED, MINUTES	FINGERS	TOES	FINGERS	TOES	FINGERS	TOES
27	26.0	10.8	17	31.8	34.4	5.3	3.8	13	36
28	27.0	4.2	35	33.7	33.1	4.9	2.8	72	60
29	25.2	2.7	30	32.7	33.4	4.9	4.2	⅔	1

Sweating tests indicated that sympathectomy was complete in all but Case 28 of operation for the relief of Raynaud's disease of the upper extremities. In this case there was slight sweating on the dorsum of a hand. In all instances the average decrease in cutaneous temperature was greater in the fingers than in the toes (including the instance in which preganglionic section had been done). In Case 27 the difference was only 1.5° C.; in Case 28 the difference was 2.1° C. and in Case 29 the difference was negligible. Superficially this would seem to indicate that preganglionic section (Case 29) produced effects on sensitivity more nearly comparable to lumbar ganglionectomy than postganglionic section did (Cases 27 and 28), but in reality sensitivity

in the fingers was about the same in all instances. For some unknown reason sensitivity was greater in the toes in Case 29 than in Cases 27 and 28.

The objection might be raised, in the light of the work of Smithwick and his associates,[37] as a result of which they concluded that the incompletely sympathectomized extremity does not become hypersensitive to epinephrine, that reliable conclusions cannot be drawn from our observations because there was evidence that cervicothoracic ganglionectomy of the upper extremities in some of our cases was incomplete. However, the fingers in all of the cases were completely sympathectomized as was shown by sweating tests; furthermore, sweating, when induced, was minimal, which indicated almost complete sympathectomy.

COMMENT

Our studies indicate that lumbar ganglionectomy (preganglionic section) does not increase sensitivity of the arterioles of toes to epinephrine significantly. It impresses us as fallacious, however, to conclude that this is true, because preganglionic and not postganglionic sympathectomy was performed. It seems much more probable that the increased sensitivity which occurs in the fingers but not in the toes is due to inherent differences in the vasomotor reactions in the fingers and toes.[13, 19, 25]

Both preganglionic section and postganglionic section of the sympathetic nerves to the hands increase the sensitivity of the digital arterioles to intravenous injection of epinephrine, and in about the same degree. The results of our studies are therefore in direct opposition to the results of similar studies by Smithwick and his associates,[37] who found that preganglionic section increased sensitivity of digital arterioles to epinephrine very much less than did postganglionic section. We have no explanation of these divergent results. It may be well to emphasize that the method of study we employed is relatively crude, but the same method was used by Smithwick and his associates. The explanation of Smithwick and his associates, that preganglionic section for Raynaud's disease effected better clinical results than ganglionectomy because the former operation did not greatly increase sensitivity to epinephrine while the latter did so, seems to us to be based, therefore, on insecure evidence. Simmons and Sheehan frankly did not accept the explanation of Smithwick and his associates. Much support would be given the thesis of Smithwick and his associates if preganglionic section routinely cured patients with Raynaud's disease of the upper extremities, but in our experience it does not. Lewis[25] and Simmons and Sheehan have made similar observations. Since sympathectomy cures Raynaud's disease of the feet routinely and does not increase sensitivity of the arterioles to epinephrine, and since

both preganglionic section (Smithwick[36]) and ganglionectomy (Adson) do not cure all patients with Raynaud's disease of the hands and do produce increased sensitivity of arterioles to epinephrine, a logical conclusion might be that all kinds of sympathectomy fail to cure Raynaud's disease of the hands because they cause increased sensitivity in that region, while sympathectomy cures Raynaud's disease of the feet because it does not increase the sensitivity of pedal arterioles to epinephrine. However, there are substantial objections to such an idea.[13, 35] In this connection it might be mentioned that in our experience vasospastic symptoms never develop in the fingers following cervicothoracic ganglionectomy for conditions other than vasospastic disease (for instance hyperhidrosis). Yet, if the digital vessels were as sensitive to epinephrine as has been implied, one would expect this to occur. In fact, we are frankly skeptical that sensitivity of arterioles to epinephrine has anything to do with failure to cure Raynaud's disease of the hands routinely by sympathectomy.

The fact that sympathectomy cures Raynaud's disease of the feet, and fails to do so in some instances of Raynaud's disease of the hands, still puzzles us. If it were because of increased sensitivity to epinephrine, why should some patients with Raynaud's disease of the hands be cured by preganglionic section, whereas some are benefited little or none, and why should some be cured by postganglionic section while some are benefited little or none? There must be other explanations. Some believe that the failure to cure Raynaud's disease of the hands by sympathectomy is due to incomplete operation, yet in such instances the operation seems as complete, as tested by ability of the skin to sweat, as it seems in some instances in which the operation produced complete cure. Moreover, as Simmons and Sheehan have pointed out, if all patients who have had incomplete operations are excluded from consideration, there remain some who reacquire vasomotor disturbances. Also, some patients who seem to have had complete operations are not cured. Furthermore, there is little correlation between clinical results and completeness of operation; an operation that almost entirely denervates the hands occasionally fails almost completely to alleviate symptoms of Raynaud's disease. Lewis has maintained, for almost ten years, that Raynaud's phenomena are not a manifestation of abnormal vasomotor tone but result from local sensitivity of digital arteries to cold. He agreed that sympathectomy is an excellent method of treatment in many instances, but he expressed the belief that the good results of operation are due to relief of normal vasomotor tone and not to relief of abnormal vasomotor tone. His expressed belief is that the central sympathetic nervous system has nothing to do with Raynaud's disease. However, his thesis does not explain cure by sympathectomy of the feet and failure of cure in some instances by sympathectomy of the hands. More-

over, as Simmons and Sheehan pointed out, Lewis'[25] thesis does not explain why vasomotor symptoms in the hands may be abolished by sympathectomy and then recur. Other observations may be pertinent. Raynaud's disease of the feet is mild and cured by sympathectomy. Raynaud's disease of the hands occurs more commonly than Raynaud's disease of the feet and is usually more severe and occasionally is not cured by sympathectomy. Is occasional failure of operation to cure Raynaud's disease of the hands due to the fact that it is more severe than Raynaud's disease of the feet? Is the fact that under ordinary circumstances the hands undergo greater exposure than the feet also a factor? No completely acceptable explanation is now available for failure of operation to cure some instances of Raynaud's disease of the hands while operation routinely cures Raynaud's disease of the feet. Certainly, it now seems definitely true that preganglionic section does not uniformly cure Raynaud's disease of the hands and that it does not cause much less increase in sensitivity of the digital arteries to epinephrine than does ganglionectomy. What appeared to be a pleasant solution of a problem has been reexamined and found to be of uncertain value. Whatever the problems connected with it may be, sympathectomy is the most satisfactory method of treatment of Raynaud's disease.

CONCLUSIONS

1. Both preganglionic section and postganglionic section for Raynaud's disease of the hands caused increased sensitivity of digital arteries to epinephrine, but the degree of increased sensitivity was about the same in both instances.

2. Sympathectomy for Raynaud's disease of the lower extremities did not significantly increase sensitivity of digital arterioles to epinephrine.

3. The problem of unsatisfactory results that occasionally follow operation for Raynaud's disease of the hands has not been satisfactorily solved by a study of sensitivity of digital arterioles to epinephrine.

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A CONSIDERATION OF THE VALUE AND INDICATIONS FOR ENCEPHALOVENTRICULOGRAPHY, WITH ESPECIAL REFERENCE TO ITS USE IN BORDERLINE NEUROSURGICAL CONDITIONS*

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INTRODUCTION

THE withdrawal of cerebrospinal fluid, either by ventricular puncture or by lumbar puncture, and the immediate replacement of the fluid by air is now a widely used method in the neurosurgical armamentarium. For this, we are indebted to the studies and communications furnished by Dandy[1] in 1918 and 1919. We shall not, however, be particularly concerned with its use as a corroborative aid in patients who are almost certainly harboring tumors, but in whom there is insufficient clinical evidence to indicate the exact extent of the lesion. There are, nevertheless, many conditions in which encephalography or ventriculography is of great aid; first, in establishing the diagnosis, and second, in determining whether a major craniotomy is necessary or warranted. Such patients come under the general group of "brain tumor suspects" and it is our intention to emphasize the importance of air injections whenever reasonable doubt exists as to the diagnosis of patients in this category. Five groups have been selected in which air injections of one kind or another are used either to establish the proper diagnosis or to indicate or contraindicate the necessity for a major operation. These groups are: (1) psychiatric cases, (2) cerebral vascular disease, (3) post-traumatic sequelae, (4) arachnoiditis and other inflammatory lesions, and (5) epilepsy. Before proceeding to a discussion of the groups mentioned, a brief review of the indications for these procedures as given by other writers will be helpful.

Indications For and Uses of Encephalography.—Encephalography is a procedure in which a series of properly exposed roentgenograms are made of the head in several positions, usually in the erect posture, immediately after the removal of all the available cerebrospinal fluid and its replacement with air by the lumbar route.[2]

It is never advisable to use this method in the known presence or even in definite suspicion of increased intracranial pressure, the tendency for the cerebellum to be drawn downward through the foramen magnum causing pressure upon the medulla and ultimate respiratory paralysis in such cases being too well known to be commented upon.*

Received for publication, July 10, 1939.

*It is scarcely necessary to add that a Queckenstedt test should rarely, if ever, be performed in the course of an ordinary lumbar puncture or in encephalography as it is of value only in the diagnosis of intraspinal lesions.

The literature is replete with the use of this method in innumerable neurological and neurosurgical conditions. Articles by Pendergrass,[2] E. Myer,[3] Adson,[4] Pancoast,[5] Grant,[6] Friedman,[7] Wechsler and Gross,[8] and Frazier,[9] among others, stress its value in the diagnosis of the nature of the essential lesion in cases of epilepsy; intracranial post-traumatic conditions; congenital lesions of the brain; birth injuries; atrophic, inflammatory, and degenerative affections of the brain; unexplained headache; and psychoneurosis.

Pendergrass[2] quotes Pancoast and Fay who found 1.2 per cent mortality in 1,529 cases of encephalography.

Not all writers on the subject agree that encephalography should be used only in those cases which do not have increased intracranial pressure. Gardner (quoted by Pendergrass[2]) performs encephalography in all cases of obscure intracranial lesions, with or without demonstrable increased pressure, clinically, except those having suspected posterior fossa lesions (a clinical differentiation which it is often difficult if not impossible to make). We cannot agree with this view for the reasons previously stated.

In summarizing the indications and uses of encephalography, as contained heretofore in the literature, most writers on the subject agree that its widest field of usefulness is in the differential diagnosis of various types of epilepsy, post-traumatic and congenital lesions, inflammatory and degenerative affections, and obscure neurological disorders in which there is no evidence of increased intracranial pressure. To this general statement might be added an additional rule employed by us, which limits the application of the procedure still further; namely, to withhold encephalography if the patient is over 50 years of age; ventriculography is probably better in more elderly individuals whether increased intracranial pressure is demonstrable clinically or not, as the latter procedure, even in patients without increased intracranial pressure, is associated with considerably less "reaction" than is encephalography.

Indications For and Uses of Ventriculography.—Ventriculography is a procedure in which a series of properly exposed roentgenograms are made of the head in several positions, usually in the horizontal posture, immediately after the removal of cerebrospinal fluid directly from the ventricles of the brain and its replacement by air.[2]

Ventriculography is the procedure of choice in obscure intracranial conditions in which there is evidence of increased intracranial pressure as shown chiefly by haziness or elevation of the optic disks, although it is well known that in 15 to 20 per cent of mass lesions of the brain there is no elevation of the optic nerve heads at any stage of the disease. However, in any series of encephalograms, or even in patients submitted to ordinary lumbar puncture, the great majority of the fatalities which result after the use of these procedures occur in pa-

tients who are harboring a brain tumor or other mass lesion, most of whom show some elevation of the disks. Therefore, in any patient in whom diagnosis is obscure, be it post-traumatic epilepsy, a probable inflammatory lesion, a tumor suspect, etc., if there be any evidence, by clinical examination or by ordinary roentgenograms of the skull, that there is increased intracranial pressure, it is much the safer procedure to use ventriculography rather than encephalography.

Many writers have previously discussed the use of ventriculography in borderline neurosurgical conditions. Among them are De Martel, Guillaume, and Paret-Raymond,[10] Vincent, David, and Puech,[11] Foerster,[12] Wanke,[13] Dahl-Inerson,[14] Pendergrass,[2] Riggs,[15] Grant,[16] and Frazier and Gardner.[17]

Frazier[17] rightly observed that, although more deaths have been attributed to ventriculography than to encephalography, it is not proper to compare the mortality statistics of these two procedures because ventriculography is or should be reserved for patients who have increased intracranial pressure, who are, therefore, greater operative risks. He believed that a spinal fluid pressure reading in the horizontal position over 260 mm. of water was a contraindication for encephalography and an indication for ventriculography. The writer suggests that an even lower reading (175 mm. of water in a relaxed patient under local anesthesia in the horizontal position) should be regarded as a "top normal" figure, beyond which encephalography is unsafe.

Pendergrass[2] quotes Grant[16] as stating that the mortality from ventriculography as a single operative procedure in 392 cases from various clinics is 8.2 per cent. However, it is only fair to state that Grant's statistics were compiled in 1923, at a time when our present knowledge of how and when to do air studies was not well established. At that time it was not uncommon to wait several days after a ventriculogram which indicated a tumor or other mass lesion, before proceeding with craniotomy, a procedure now realized to be highly fatal in its tendencies. Pendergrass[2] also states that Dandy believes that only 40 per cent of brain tumors can be localized by neurological examination; whereas, Frazier believed that 60 to 70 per cent could be localized without resorting to an air injection.

In summarizing the indications for and uses of ventriculography as contained heretofore in the literature, it is generally agreed that the main value of the procedure is in the localization of a tumor or other intracranial mass lesion in the presence, usually, of increased intracranial pressure or to obtain a more exact localization than can be made by neurological studies. It cannot be emphasized too often or too vigorously that if such air injection indicate a mass lesion, in the presence of increased intracranial pressure, further operation for the removal of the lesion should be carried out on the same day, if at all possible. Even with this rule in use, the mortality rate of ventricu-

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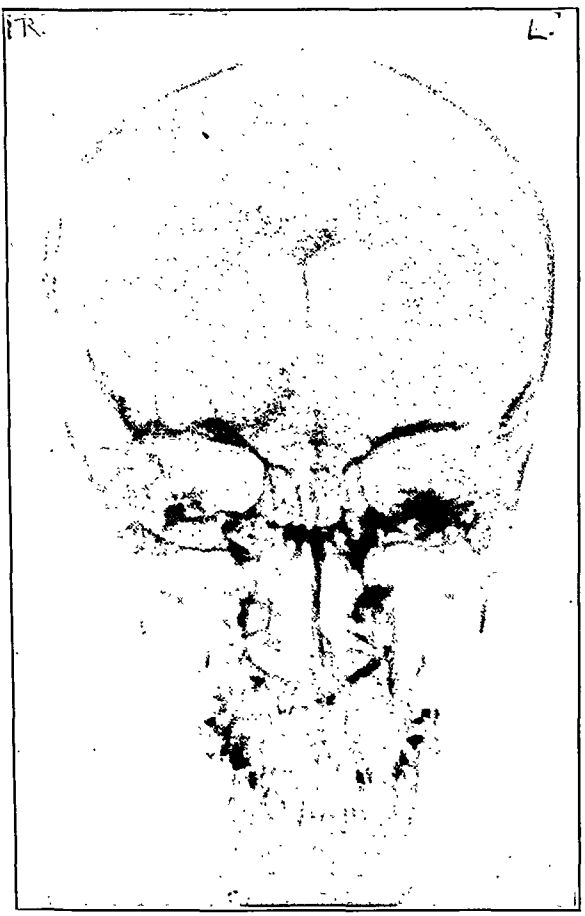
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system (Figs. 1, 2, and 3). Further questioning revealed the fact that there was a marked social maladjustment and also that the patient had worked with a girl who later developed and died of a brain tumor. She was discharged with a tentative diagnosis of multiple sclerosis or possibly a pontile tumor.

Follow-up examination could not be obtained.



Figs. 1, 2, and 3.—Case 2. Normal ventriculograms. These films may be considered a model for comparison with subsequent films. Notice in Fig. 1 that the normal butterfly shape is quite apparent and the size of the ventricles is within normal limits.

Comment.—Ventriculography was undertaken in this instance largely because of headaches, vomiting, and edema of the left optic disk and because the whole clinical picture did not fit in with typical multiple sclerosis. The findings previously mentioned may possibly indicate a beginning posterior fossa tumor, but certainly the ventricular and clinical evidence, to date, is too equivocal to warrant subjecting the patient to a major surgical intracranial procedure. One is certainly justified in pursuing a policy of "watchful waiting" with fairly frequent clinical check-up examinations in such a case; whereas, if the ventricular system had shown marked generalized dilatation, a sub-

ital exploration would have been undertaken at once with the able demonstration of a cerebellar tumor.

ASE 3.—*Patient with headache, hypersomnia, and emotional instability. Frontal tumor suspect. Normal ventriculogram. Discharged improved. Tentative diagnosis: probable functional neurological disorder.*

Miss K., aged 26 years, a clerk, was first admitted Sept. 30, 1932, complaining headaches. The blood pressure was 160/110, but, as there was no evidence of perthyroidism, for which she was referred to the clinic, she was sent back to her mily physician for further observation. She was readmitted in February, 1933, mplaining of hypersomnia, emotional and personality changes. A frontal lobe

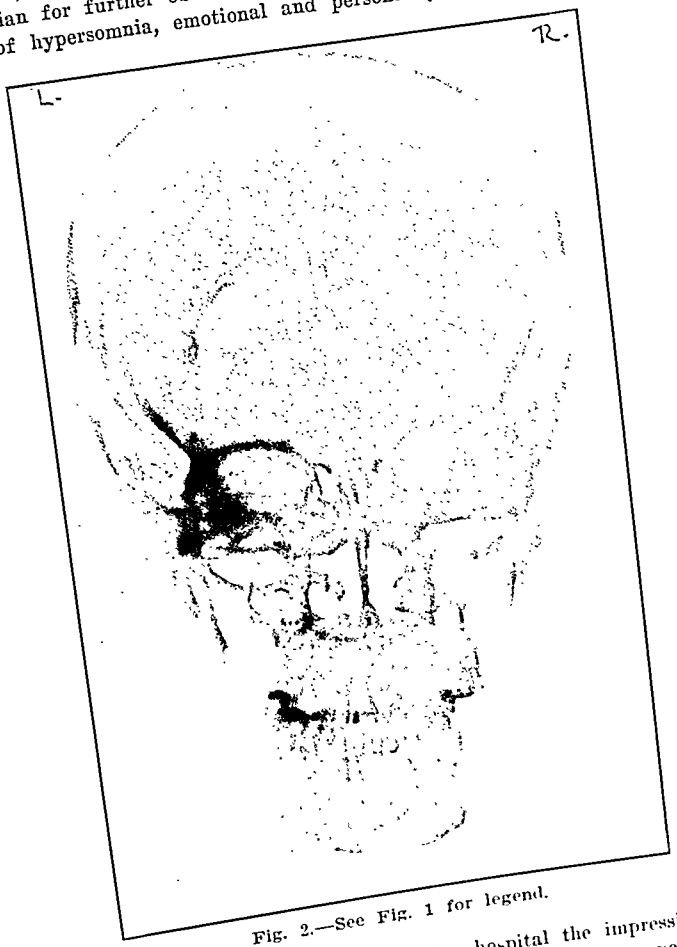


Fig. 2.—See Fig. 1 for legend.

tumor was tentatively considered. At another hospital the impressions had been narcolepsy or hysteria. On March 4, 1933, a ventriculogram was performed which revealed normal ventricles. She was discharged six days later, having had no periods of hypersomnia or other untoward symptoms while in the hospital. She was still classified as a brain tumor suspect but with the probability that she had a neurosis.

The patient's mother reported by letter, March 16, 1939, that the patient appears to be quite well since leaving the hospital, six years previously. She is active in club work and drives her automobile on long trips without becoming unduly tired.

Comment.—It is impossible to rule out a brain tumor (without air injection) in a patient whose dominant symptoms are mental or psychiatric unless the whole clinical picture conforms to a well-recognized psychosis. Latent or unrecognized atypical encephalitis may be the cause of this patient's disability, although her present well-being almost certainly establishes the diagnosis as a neurosis. On the other hand, innumerable cases of frontal lobe or diencephalic tumor have had more or less the same clinical picture as this patient presented and many cases of frontal or interbrain (diencephalic) tumor, especially in children, have been treated as "encephalitis" or neurosis with disastrous results. Careful judgment must be exercised as to the advisability or justification of air studies in patients with mental symptoms alone.

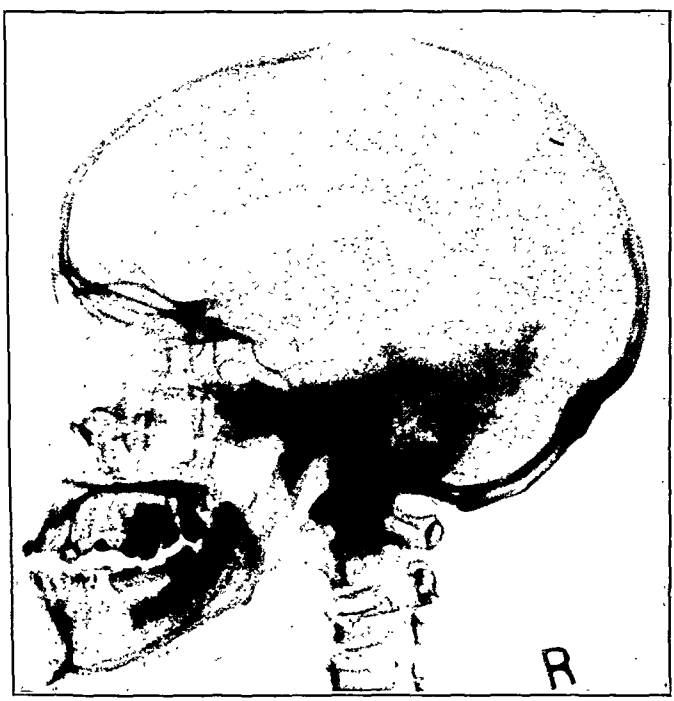


Fig. 3.—See Fig. 1 for legend.

II. CEREBRAL VASCULAR LESIONS

CASE 4.—*Convulsive seizures involving the left side of the body. Neurological examination negative. Ventriculogram normal. Death ten days after ventriculography. Post-mortem: no intracranial mass lesion. Marked arteriosclerosis. Incidental primary carcinoma of bronchus with no demonstrable metastases to any other part of the body.*

Mrs. D., aged 62 years, housewife, was first admitted June 8, 1933, complaining of cough and loss of weight. Two weeks before admission she had fainted; she had also suffered from vertigo. The patient presented clinical evidence of hyperthyroidism and a first stage thyroidectomy was performed on Aug. 14, 1933.

She was readmitted on Oct. 3, 1933, with a complaint of convulsive seizures of the left side. Neurological examination did not reveal anything of significance. A ventriculogram was performed which demonstrated no definite signs of tumor. She became irrational and died ten days after the air study. Post-mortem examination showed no cerebral lesion other than rather marked arteriosclerosis, but a primary carcinoma of the bronchus was discovered which apparently had not metastasized to any other organ.

Comment.—Cerebral vascular lesions notoriously imitate intracranial tumor in the symptoms which they produce, a fact emphasized by Horrax.[18] Convulsive seizures, hemiplegia, hemianopsia, stupor, etc., all can occur equally well with one or the other pathologic entity. The most astute clinician cannot always be sure as to the type of lesion present without actual visualization of the ventricular system. In the case just described, encephalography might have been done, but the patient's age precluded it. The primary carcinoma of the bronchus had nothing to do with the cerebral symptoms.

CASE 5.—*Aphasia and numbness of the right arm. Skull x-ray suggestive of meningioma. Patient discharged without air injection as a probable vascular lesion. Readmitted with paresis of right face and arm. Ventriculogram demonstrated no mass lesion (moderate generalized ventriculor dilatation). Presumptive diagnosis: cerebral arteriosclerosis with thrombosis of the left middle cerebral artery.*

Mr. U., aged 65 years, retired, was admitted Jan. 26, 1933, complaining of aphasia and numbness of the right arm of three months' duration. There was tenderness over the left parietal area and x-ray of the skull showed abnormal vessels in the left parietal region suggesting a meningioma. The fundi were normal. A ventriculogram was not thought necessary and the patient was discharged because the weight of evidence appeared to favor a vascular lesion (thrombosis).

He was readmitted on May 17, 1933, at which time he showed euphoria, right facial palsy, and paresis of the right arm. Visual fields were normal. There was a history of violent seizures during which he attacked members of his household and attendants. A ventriculogram was performed which revealed generalized moderate ventricular dilatation (Fig. 4), probably due to cerebral atrophy incident to arteriosclerosis. He was discharged to his home; the presumptive diagnosis was cerebral arteriosclerosis with concomitant thrombosis of the left middle cerebral artery.

Follow-up report, February, 1934: Patient was seen and examined. His condition was the same as at the time ventriculography was performed. There was no evidence of an expanding intracranial lesion.

Comment.—The definite organic signs which this patient had, aphasia, paresis of the right face and arm, and numbness of the right arm, together with x-ray evidence of abnormal vessels in the left parietal region suggestive of a meningioma, certainly warranted an air injection to rule out a tumor or other intracranial mass lesion. His age again precluded an encephalogram which might, otherwise, have been considered in the absence of demonstrable clinical signs of increased intracranial pressure. The generalized ventricular dilatation, together with the euphoria, vio-

lent seizures, and other mental symptoms, supports the presumptive diagnosis previously stated.

III. POST-TRAUMATIC SEQUELAE

CASE 6.—*Post-traumatic headache and vertigo. Encephalography failed to outline ventricles. Ventriculogram carried out later revealed a normal ventricular system. Diagnosis: post-traumatic encephalopathy.*

Mr. A., aged 24 years, single, was admitted Dec. 1, 1932, complaining of vertigo and headache following a head injury in April, 1932, at which time he is said to have sustained a skull fracture. Examination on admission showed nystagmus to right

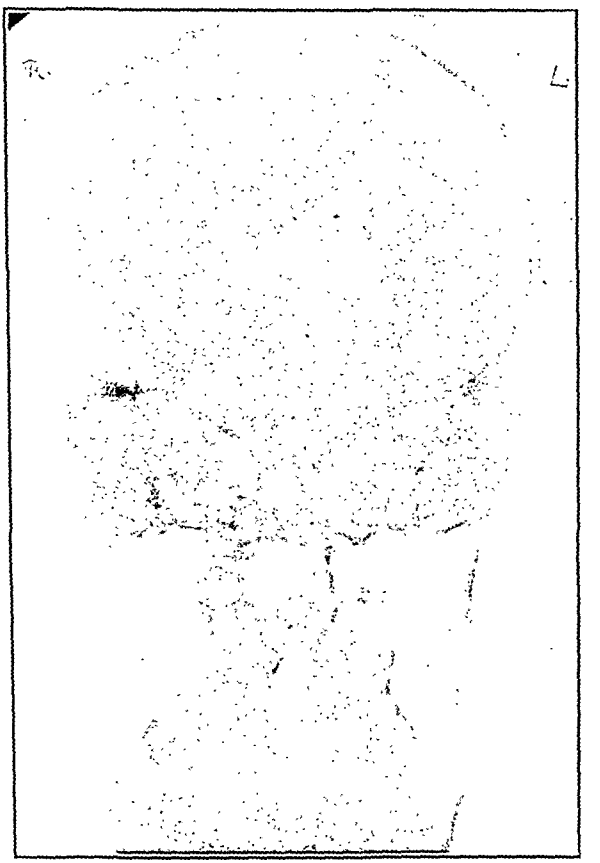


Fig. 4.—Case 5. Ventricles somewhat dilated. Observe that there is no ventricular distortion to suggest a left cerebral mass lesion, but the left ventricle is drawn upward on the side of thrombosis (left). Ventricular dilatation is common in cerebral atrophy incident to arteriosclerosis.

and left. The optic disks were slightly edematous. The impression at this time was that of an old head injury with probable midbrain or pontile contusion. He was discharged and advised to take mild sedatives for his headaches.

He was readmitted on July 13, 1933, complaining of headache and vertigo. Encephalography showed considerable air scattered over the cortex but no ventricular air. There were no areas of localized cerebral atrophy.

He was seen again in September, 1933, at which time he stated that the headaches were still severe. Ventriculography was recommended chiefly to rule out a sub-

dural hematoma; this revealed a normal ventricular system. He was discharged eight days later with the headache and vertigo considerably relieved.

Follow-up report, November, 1936 (three years after the ventriculogram): Patient now having "spells" with loss of consciousness. Slight hemihypesthesia of right side. Another air study advised but refused.

Comment.—This patient was first seen eight months after the original cerebral trauma. No localizing signs were present on examination. Encephalography was preferred, not only for diagnosis but also for its therapeutic effect. In this case the ventricles were not outlined, so recourse was had at a later date to ventriculography, chiefly to rule out a subdural hematoma. This revealed a normal ventricular system and one is thereby assured of not overlooking an intracranial mass lesion.

CASE 7.—*Post-traumatic headache. Encephalogram interpreted as within normal limits. Temporary relief. Ventriculographic procedure revealed a left subdural clot in the course of making the burr opening; ventricular shift to the right side. Headache again relieved. Later, a left subtemporal decompression performed with release of xanthochromic fluid.*

Mr. T., aged 47 years, married, was first admitted in March, 1933, complaining of constant headache which began after a head injury fourteen months before admission to the Clinic. At the time of injury there was also a left facial palsy as well as weakness and tingling of the left forearm and hand. Examination at the Clinic was negative and an encephalogram was made. He experienced great relief but returned five months later, in August, 1933, with a recurrence of the headache. Bilateral ventriculography was performed as the previous encephalography had not been entirely satisfactory and this revealed a subdural liquid collection of old blood on the left side which was drained through the ventriculogram opening. The anteroposterior view (Fig. 5) clearly showed the slight indentation and deviation to the right of the left lateral ventricle with compensatory slight relative dilatation of the right lateral ventricle caused by the left-sided subdural collection. The headache was again relieved. He was readmitted for the third time in February, 1934, with recurrence of the headache and a left subtemporal decompression was performed. On opening the dura, there was an outpouring of fluid under marked pressure from the subdural space. It was faintly xanthochromic. The arachnoid over the sylvian vessels was thickened and gray. He made a rapid convalescence and left the hospital twelve days after operation, feeling quite well.

Follow-up report, November, 1934: Patient's headaches recurred a few months after decompression. He was rapidly declining but was unable to come back for possible further treatment.

Comment.—The finding of a subdural hematoma on the left side in the course of doing the ventriculogram was a fortunate occurrence. In most clinics ventriculography is done through posterior parietal or occipital burr openings and, occasionally, a clot may be missed, as its posterior margin may not extend so far posteriorly. Coleman[19] believes that the best location in searching deliberately for a subdural clot is in the superior temporal region; whereas, Horrax[20] and Horrax and Poppen[21] make incisions in the parieto-occipital region. In Peet's clinic,[22] ventriculography is done routinely at Keen's point just above

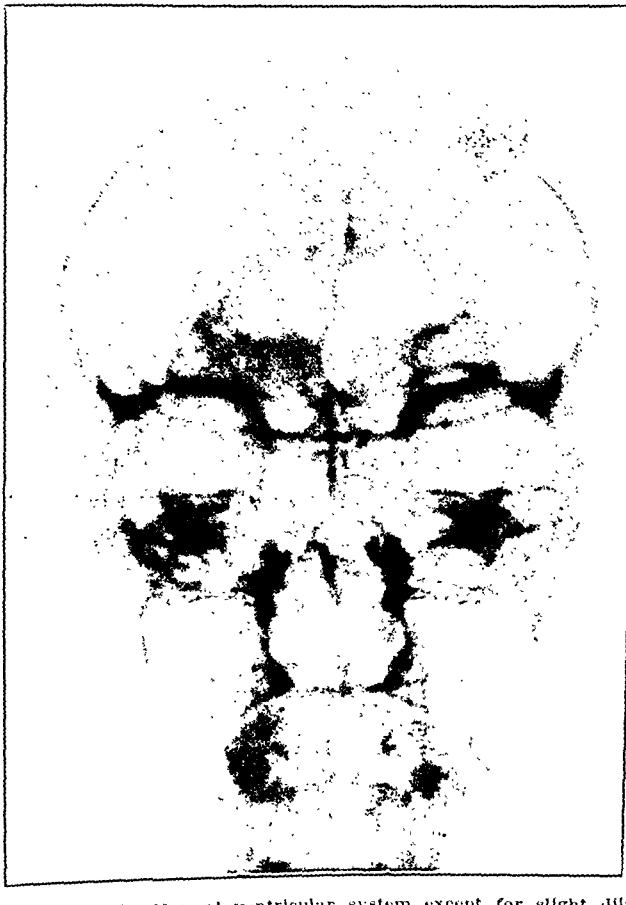
and posterior to the ear where an unsuspected clot would almost certainly be found in the course of making a ventriculogram. Peet knows of no subdural hematoma that has been missed in his clinic because the ventriculogram burr opening was placed too far posteriorly. The point to be emphasized is that an osteoplastic flap for the evacuation of a subdural hematoma in a comatose patient may well result fatally; whereas, simple drainage through a burr opening may result in cure.



Fig. 5.—Case 7. Note the slight depression of the left lateral ventricle compared with the right and the very slight but definite shift of the entire ventricular system to the right caused by the left subdural clot.

If the ventriculogram burr opening discloses no clot, ventriculography must be performed, followed by an osteoplastic flap, when indicated, in the absence of any traumatic history. We have (December, 1936) had such an experience in another patient. The clot unfortunately did not extend quite far enough posteriorly to the point of the ventriculogram burr opening. The patient was unconscious and in

poor condition. There was no history of trauma. A ventriculogram was performed and the plates showed a shift to the right as in a left cerebral mass lesion. Immediate craniotomy disclosed an enormous liquid subdural hematoma which was evacuated and drained, but the patient succumbed two days later without ever having regained consciousness. Another similar case has been reported recently.[23] In view of these experiences, it would seem advisable, in similar obscure cases, to perform ventriculography at Keen's point, at which site an entirely unsuspected subdural clot would almost certainly be uncovered and could probably be evacuated through the simple burr opening made in the course of the intended ventriculogram.



Figs. 6 and 7.—Case 8 Normal ventricular system except for slight dilatation of the third ventricle (Fig. 6).

In the case described above (Case 7), a left subtemporal decompression was performed six months after the evacuation of the clot because of persistence of headache due to the pent-up subdural fluid and consequent disturbance of the cerebrospinal fluid circulation. We have (1937) had an exactly similar experience.

The cause of the patient's rapid decline (at last report) is obscure unless it be due to cerebral atrophy and degeneration incident to the patient's rather severe head injury originally sustained in 1932.

CASE 8.—*Patient with post-traumatic personality changes and possible manic-depressive psychosis. Brain tumor suspect (? frontal lobe). Encephalogram normal (slight dilatation of third ventricle). Slight depressed fractures of the vault. Discharge diagnosis: Probable manic-depressive psychosis with post-traumatic cerebral injury.*

Mr. T., aged 18 years, a shoe salesman, was admitted Nov. 27, 1933, complaining of nervousness following a head injury six years previously, at which time he was unconscious for five days. For the last three years there had been definite personality changes. Examination suggested a possible manic-depressive psychosis in addition to post-traumatic sequelae. Brain tumor of one or the other frontal lobes

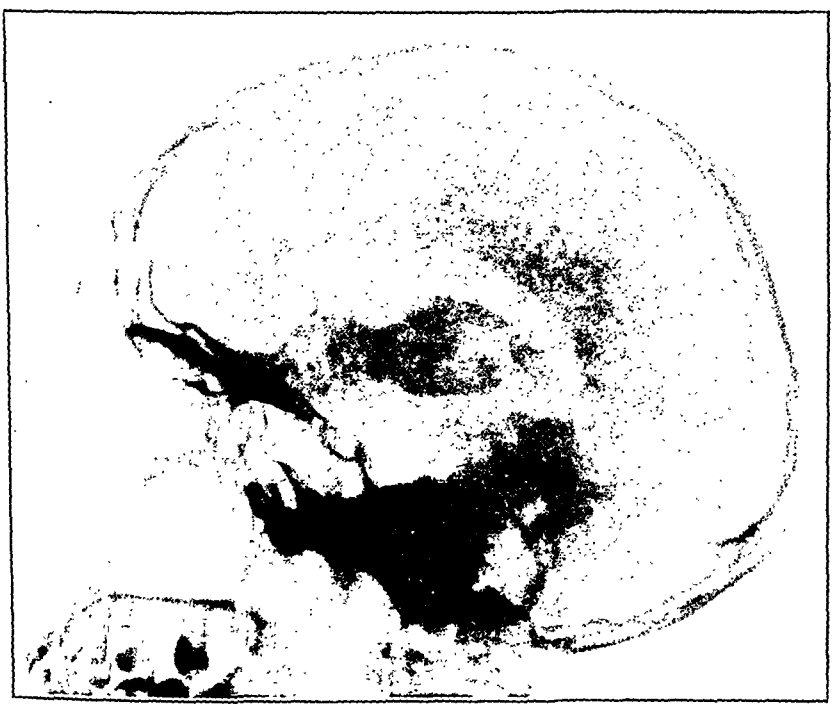


Fig. 7.—See opposite page for legend.

was a more remote possibility. Encephalography was advised. The plates were normal (Figs. 6 and 7) except for slight dilatation of the third ventricle in the anteroposterior view (Fig. 6) and slight depressed fractures of the right parieto-occipital and left parietal areas. These findings were considered to have little or no surgical significance. He was discharged with a diagnosis of manic-depressive psychosis, post-traumatic cerebral injury, and slight depressed fractures of the vault.

Letters to the patient and to his doctor one year later were not answered.

Comment.—To have operated upon this patient's slightly depressed fractures would have been an irrelevant and undesirable procedure as it almost certainly would have accomplished no good and might have

resulted in his ascribing all his disability to the fractures with the possibility of his developing a "fixation complex" concerning them. The case probably represents a post-traumatic syndrome, engrafted on an individual of the constitutionally psychopathic inferior type. Such patients (as Cases 1, 2, and 3) can be eliminated from the tumor group only by an air injection. Even if air studies be interpreted as normal, such patients should be re-examined at frequent intervals thereafter to rule out a surgical lesion. Perhaps the greatest value of air injections, apart from exact localization of a mass lesion, is in such problem cases as the one just described, in determining, for the time being, whether or not a tumor or its equivalent is present.

IV. ARACHNOIDITIS

CASE 9.—*Failing vision, mild frontal headache, and high choked disks. No objective localizing signs. Ventriculogram normal. Right subtemporal decompression to relieve the choking revealed a large subarachnoid fluid collection as the cause of the increased intracranial pressure. Considerable subsidence of the choked disks before discharge.*

Mrs. M., aged 31 years, housewife, was admitted May 4, 1934, complaining of failing vision of three months' duration. There was mild transient headache across the frontal region. Neurological examination was negative except for bilateral choked disks of 5 to 6 diopters. Ventriculography was performed: the plates were interpreted as within normal limits (Fig. 8). Because of the high grade of choked disks and headache, a right subtemporal decompression was performed the same day. When the dura was opened, a great excess of fluid was released from the subarachnoid space. The sylvian vessels were not displaced and the convolutions appeared normal. Eight days after operation the optic disks appeared greatly improved. She was discharged nine days postoperatively with headache relieved and the haziness of vision having completely disappeared.

It is presumed that this patient had no tumor; first, because there was definite evidence at operation of a chronic arachnoiditis of sufficient degree to explain her symptoms, and second, because, if a tumor had reached such proportions as to have caused so high a degree of choking, there would almost certainly have been some dilatation or distortion of the ventricular system as demonstrated by ventriculography.

Follow-up examination, March, 1935: The patient had improved in all respects since decompression. Her fundi showed no elevation of the optic disks; only occasional mild headaches occurred.

Comment.—If the ventriculogram be normal in the presence of choked disks, a subtemporal decompression is always indicated to relieve pressure and preserve vision. If the case be that of an early tumor, localizing symptoms will probably develop later and vision will have been preserved in the meantime. In this case the result following decompression almost certainly removes the case from the "tumor suspect" group, for the rapid subsidence of the choking after release of the fluid argues against tumor and suggests that the pent-up fluid was the major, if not the only, cause of the patient's disability.

CASE 10.—*Prolonged left-sided mastoid infection (mastoidectomy). Bilateral choked disk (3½ diopters) of several weeks' duration. Brain abscess suspect. Normal ventriculogram. Recession of choked disks without further operation. Diagnosis: post-mastoiditic arachnoiditis.*

Miss M., aged 12 years, a school girl, was admitted May 14, 1934, with a long history of mastoid infection on the left side necessitating three operations elsewhere, with subsequent development of choked disks (5 diopters) which suggested the possibility of a brain abscess. On admission to the Clinic she showed 3½ diopters' elevation of the disks. The preoperative note (Dr. Horrax) stated that,

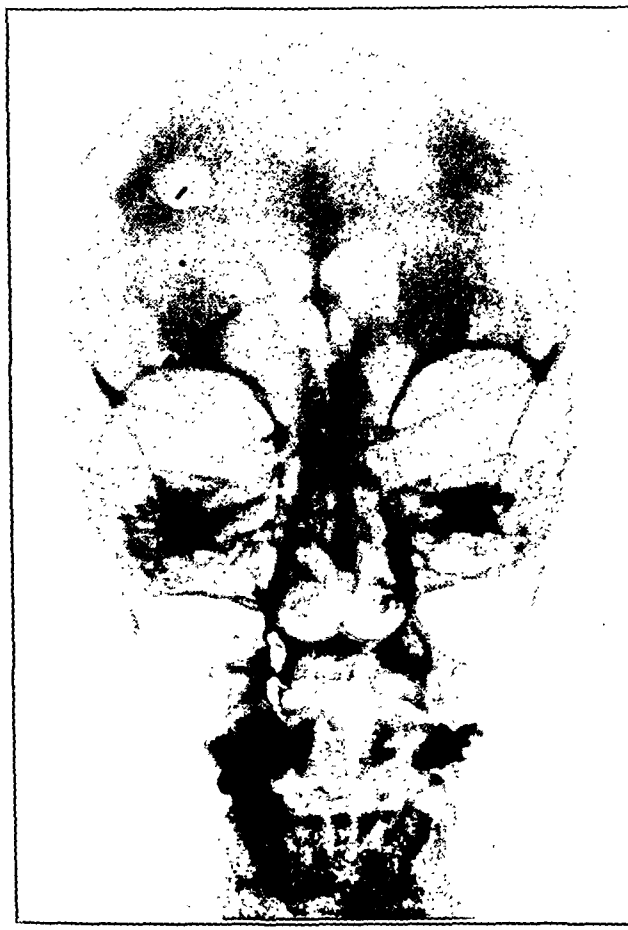


Fig. 8.—Case 9. Ventricular system within normal limits. Because of the high grade of choked disks, *subtemporal decompression* was performed immediately after ventriculography with release of a large amount of subarachnoid fluid and rapid subsidence of the papilledema.

although there possibly was a brain abscess, the lesion was more likely to be an arachnoiditic process following mastoiditis. The ventriculogram made two days after admission was normal. Thereafter, the fundi receded to 1 diopter elevation within one month after the operation.

Follow-up examination, December, 1935 (one and one-half years after ventriculography): She has been perfectly well in every way and stands at the top of her class in school. She is active in all sports. The optic disks are normal.

thereafter, the convalescence was uneventful. He was discharged fifteen days following the first operation, having had no further seizures.

Follow-up reports: (1) December, 1934, a letter from the patient stated that he was slowly regaining his strength. No mention was made concerning further seizures. (2) December, 1938, condition about the same as before operation; having seizures about once per month.

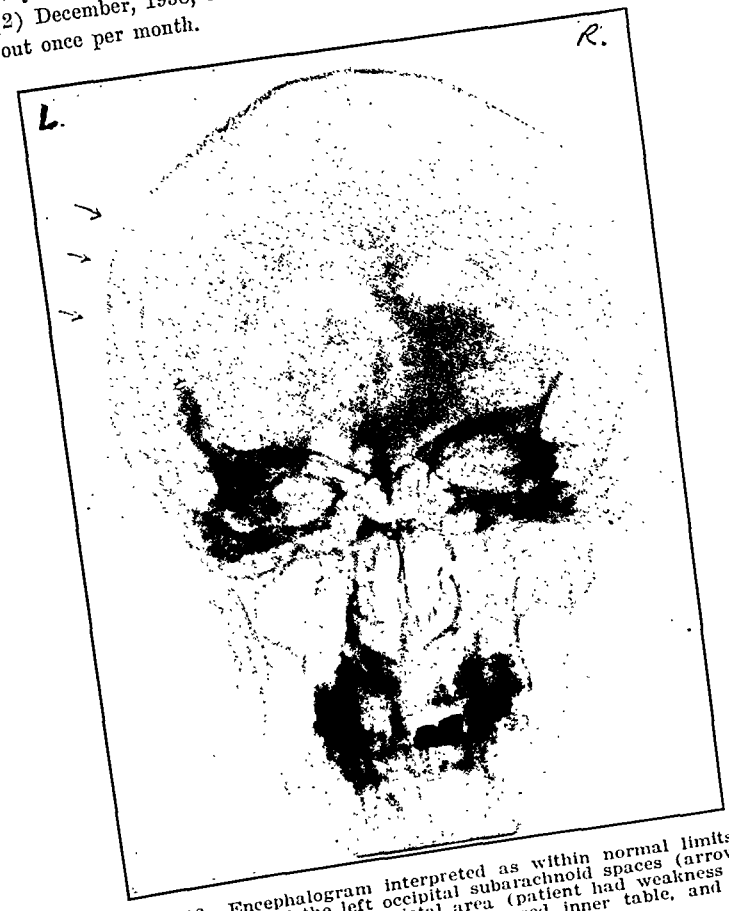


Fig. 9.—Case 12. Encephalogram interpreted as within normal limits except for slight increase in the size of the left occipital subarachnoid spaces (arrows). Operation five months later over the left parietal area (patient had weakness of the right arm) disclosed post-traumatic adhesions, a depressed inner table, and an enlarged cortical vein as causes of the convulsions.

Comment.—Jacksonian epilepsy usually demands exploration of the appropriate motor cortex even if air injection by either route is apparently normal. In this case the definite pathologic changes demonstrated at operation fully warranted exploration, although, as events turned out, the patient was unimproved at last report. All of the findings (with the possible exception of the enlarged cortical vein) were post-traumatic in origin. Occasionally, air injection in post-traumatic cases demonstrates a definite "pulling out" of a ventricle toward the cortical surface. Operation usually demonstrates a cortical scar, often necessitating excision down to the ventricle itself, together with repair

of the accompanying dural defect. The results in such cases are usually excellent. This latter lesion frequently follows compound depressed skull fractures in which the cortex and the dura have been lacerated. In the case described above the lesions were of a somewhat lesser magnitude, but nevertheless quite capable of inducing the disabling epileptic attacks.

DISCUSSION

It is, of course, quite possible that some of the presumptive diagnoses mentioned above may have to be modified in the light of future developments in individual cases. This is true, of necessity, just as it is in any list, for example, of verified intracranial tumors in which a certain proportion of the cases would be temporarily listed as unverified brain tumors or even as brain tumor suspects. One must have, however, a working classification in order that patients may be properly managed when first seen and examined.

Although none of the psychiatric cases described in this paper (Cases 1, 2, and 3) have been proved, to date, to have had a tumor, such a lesion is occasionally discovered. An excellent illustration of this is recorded in the paper by Horrax, Yorshis, and Lavine.[25] A woman 43 years of age, formerly of a high degree of intelligence, had been in a mental institution at intervals for many years with a diagnosis of manic-depressive psychosis. Skull plates showed an enormous calcified tumor in or overlying the left cerebral hemisphere. A ventriculogram was done primarily to determine whether the brain was definitely encroached upon or not; this showed a definite shift of the ventricular system toward the right side. A two-stage removal of an intradural cholesteatoma was followed by remarkable mental improvement so that she was discharged from the sanatorium. She never showed any neurological abnormality; the psychiatric features were the only findings. It is suggested, therefore, that it would be a good plan to take at least one lateral x-ray film of the skull in all psychiatric cases when first admitted to mental institutions so that obvious intracranial tumors of this and other types could be detected and eradicated as soon as possible.

As emphasized in the comment on Case 4 and by Horrax[18] in his introduction to a review of three characteristic cases, cerebral vascular disease frequently closely simulates intracranial tumor in many of its clinical manifestations and resort must occasionally be had to air injections to establish the diagnosis. Cerebral vascular lesions are not invariably apoplectic in onset. On the other hand, intracranial tumors may resemble an apoplexy if a hemorrhage occur in the tumor; this develops, however, much less frequently than is usually supposed. Furthermore, all intracranial tumors are not characterized by progressive loss of neurological function for curious intermittent or sta-

tionary symptoms and signs may be seen in tumor cases which closely imitate cerebral thrombosis. Finally, headache, vomiting, vertigo, choked disk, aphasia, hemiplegia, and ataxia may be present in many cases of malignant hypertension as stated by Pepper[26] and will require a ventriculogram to rule out a brain tumor, although the latter lesion is rarely associated with vascular hypertension per se.

Case 7 clearly illustrates the management of intracranial post-traumatic sequelae. First, an encephalogram was done for its diagnostic and therapeutic effects. After temporary relief, the symptoms recurred and a ventriculogram was performed primarily to exclude the presence of a subdural hematoma. As a liquid clot was found, it was drained through the ventriculogram burr opening. A few months later, the patient returned for a subtemporal decompression on the side of the previous clot because of recurrence of headaches. This is an unusual experience as the great majority of subdural hematomas can be cured permanently by evacuation through a small burr opening.[19, 21, 22]

The diagnosis of arachnoiditis should always be made by exclusion. In Case 9 such a condition is almost certainly correct since so high a degree of choked disks, if caused by a tumor or other mass lesion of the brain, would almost surely have caused some distortion or dilatation of the ventricular system. To support this supposition was the large abnormal amount of fluid released at the time of the right subtemporal decompression which was performed, primarily, for relief of the headache and to preserve vision. In most instances, time alone and the continued well-being of the patient are the best criteria for the accuracy of the diagnosis of arachnoiditis, as demonstrated by the follow-up note in this case.

The chief causes of epilepsy, according to Dandy,[27] are (a) congenital, (b) neoplastic, (c) inflammatory, (d) traumatic, (e) vascular, and (f) degenerative brain lesions. Case 11 demonstrates the wisdom of listing all adult patients with convulsions as brain tumor suspects until a tumor ultimately is disproved or verified. Case 12 includes two of the lesions listed above as the causes of epilepsy: traumatic and vascular.

SUMMARY

1. The value of and indications for encephalography are listed following a review of the literature. It might be summarized by stating that, if increased intracranial pressure be clinically demonstrable or even strongly suspected, this procedure is contraindicated. Even the determination of the spinal fluid pressure by ordinary lumbar puncture is somewhat dangerous in such cases. The practice of doing a Queckenstedt test *on all* patients subjected to encephalography or even lumbar puncture, a method still prevalent in certain hospitals, cannot be too strongly condemned as it yields little or no pertinent information

and may do irreparable harm. The Queckenstedt test should be reserved almost entirely for the demonstration of an *intraspinal block* such as is found in spinal cord tumors and fracture-dislocation of the spine.

2. The indications for and uses of ventriculography are also listed. This procedure is indicated in any patient who presents evidence, however slight, of increased intracranial pressure in the absence of definite signs pointing to a localized lesion. One particular reason for utilizing it in these cases is that, if respiratory or other difficulties supervene following a ventriculogram, relief may be obtained by immediate tapping of the ventricles through the original burr openings; whereas, such a procedure is impossible in encephalography unless cranial burr openings are subsequently made. Furthermore, it has been shown conclusively in most neurosurgical clinics that radical operation for the removal of a tumor should follow the ventriculogram without delay. It is true that in many cases (15 to 20 per cent) of intracranial mass lesions, no evidence of increased intracranial pressure is demonstrable either by x-ray or by clinical examination. If such a lesion be suspected, it is, of course, better to utilize only ventriculography for the localization of the lesion.

3. Five groups of cases are presented to illustrate the value of encephalography or/and ventriculography in determining the necessity for major operation in borderline neurosurgical cases. Representative examples of each group are outlined, the course of the illness in each case is followed, and it is emphasized that, even with an air study, the ultimate diagnosis is not always clear at the time of any single hospitalization period. On the other hand, these relatively minor surgical procedures are often of the greatest aid in deciding upon the immediate disposition of the individual case.

4. It is suggested that, if the above separate indications for encephalography and ventriculography be followed universally, the mortality of 1.2 per cent for the former and of 8.2 per cent for the latter procedure should be still further reduced.

The writer wishes to gratefully acknowledge the aid of Dr. Gilbert Horrax in the preparation of this paper. His many suggestions and encouragement made its completion possible.

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POSTOPERATIVE MYXEDEMA

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ALTHOUGH there is a great deal in the literature concerning the association of chronic thyroiditis in the form of Hashimoto's and Riedel's strumitis with the occurrence of postoperative myxedema, the literature dealing with the histology of the thyroid gland in those cases in which postoperative myxedema develops is scanty. Smith, Clute, and Strieder reported a series of 100 cases of thyroidectomy, in which series postoperative myxedema developed in fifteen cases, and the authors were impressed with the presence of large acidophilic cells in those cases in which myxedema occurred. They felt that the high incidence of myxedema in their series was probably due to the removal of larger amounts of tissue and to the administration of iodine after thyroidectomy. They found no very close correlation, but a somewhat suggestive parallel, between the degree of strumitis and the incidence of myxedema. McClure and McGraw felt that the amount of thyroid tissue left at operation is the principal factor which determines a normal, recurrent, or hypothyroid state after thyroidectomy. Conklin agreed with McClure and McGraw and stated further that in cases of thyroiditis a large amount of thyroid tissue should be left at the time of operation. He also made the point that, in operations in which a great deal of suturing is required or those which are followed by prolonged drainage or infection, postoperative myxedema is most likely to occur. Jackson contended that in the majority of cases of postoperative myxedema, if not in all, the condition develops because of thyroiditis, which destroys the remnant of the gland left at the time of operation.

The presence of collections of lymphocytes and germinal centers within the thyroid gland of patients with Graves' disease is generally accepted and these collections are said also to occur in normal thyroid glands (Jaffe). The exact significance of these lymphocytes is a moot question, however. Warthin included these in the syndrome of what he called the "Graves constitution," associated with an enlarged thymus and generalized lymphatic hyperplasia. Jaffe considered them secondary phenomena that can be linked to degeneration, involution, hypoplasia, or functional disturbance of the gland. Hellwig expressed the opinion that the collections of lymphocytes in exophthalmic goiter are a local response to hyperplasia and hypersecretion of the thyroid itself. None of these workers associated the presence of considerable numbers of lymphocytes in the thyroid gland at the time of operation with the development of postoperative myxedema.

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Received for publication, June 13, 1939.

Boothby and Plummer stated that there is no clear line of demarcation between the degree of fibrosis and lymphocytic infiltration that can be definitely designated as thyroiditis and the degree of fibrosis and lymphocytic infiltration that is characteristic of exophthalmic goiter. They expressed the opinion that the incidence of myxedema as a postoperative sequela to exophthalmic goiter apparently is roughly proportional to the incidence and degree of chronic thyroiditis. On the other hand, they stated that myxedema sometimes occurs even when no recognizable chronic thyroiditis was present in the tissue removed. Pemberton (Brenizer) stated that in about 10 per cent of all cases of exophthalmic goiter histologic study shows a picture of round-cell infiltration and fibrosis in a degree sufficient to warrant a diagnosis of thyroiditis. In most instances, he said, it is of a mild degree, but not infrequently it is marked and in 0.5 per cent of cases it is very marked. Myxedema invariably develops in these cases, he stated. Broders expressed the opinion that the collections of lymphocytes within the thyroid glands of patients suffering with exophthalmic goiter are a reaction to something within the gland itself, probably thyroxin, or, in other words, that these cells are an attempt by nature to control the thyrotoxicosis.

In this study the term thyroiditis is used to denote collections of lymphocytes within the thyroid gland in sufficient quantities to be an outstanding feature of the histologic picture. An attempt will be made to show the association of their presence with the development of postoperative myxedema.

The material in this paper is based on the histologic findings in the thyroid glands of 238 patients in whom clinical myxedema developed after thyroidectomy. It includes 207 cases of exophthalmic goiter, 19 cases of adenomatous goiter without hyperthyroidism, 1 case of adenomatous goiter with hyperthyroidism, 4 cases of carcinoma of the thyroid gland, and 7 cases in which the thyroiditis was so marked that the classification of the parenchyma was not otherwise apparent. To demonstrate the occurrence rate of postoperative myxedema, all patients who were operated upon in the years 1925 to 1934, inclusive, and who developed postoperative myxedema as late as Jan. 1, 1938, are included in Table I.

Of the 238 cases in the total group, 170 cases (71 per cent) showed a definite amount of thyroiditis. Of the cases of exophthalmic goiter, 72 per cent of the patients had definite thyroiditis at the time of operation. In the group of adenomatous goiters without hyperthyroidism, 66 per cent of the patients showed thyroiditis. The 1 patient with adenomatous goiter with hyperthyroidism who developed myxedema after operation showed no evidence of thyroiditis. Thyroiditis was present in 2 of the 4 cases of carcinoma of the thyroid.

The average interval which elapsed from the time of thyroidectomy until the patient returned to the Mayo Clinic with myxedema, in the group of 68 cases in which thyroiditis was not present, was 18.4 months. In all cases in which thyroiditis was present, the average interval was

TABLE I

RATE OF OCCURRENCE OF POSTOPERATIVE MYXEDEMA (1925 TO 1934, INCLUSIVE)

DIAGNOSIS	NUMBER OF CASES	DEFINITE THYROIDITIS PRESENT (PER CENT)	RATE OF OCCURRENCE OF POSTOPERATIVE MYXEDEMA (PER CENT)
Exophthalmic goiter	161	72	2.1
Adenomatous goiter with hyperthyroidism	1	0	0.06
Adenomatous goiter without hyperthyroidism	12	66	0.3

14.1 months. These cases were divided into groups according to the severity of the thyroiditis at the time of operation, and Table II was obtained. Although the number of cases of severe thyroiditis is small, there seems to be a relationship between the amount of thyroiditis present and the interval elapsing before the patient returned to the Mayo Clinic.

TABLE II

SEVERITY OF THYROIDITIS	NUMBER OF CASES	INTERVAL BETWEEN OPERATION AND PATIENTS' RETURN WITH MYXEDEMA (MO.)
None	68	18.4
Moderate	154	14.7
Marked	13	9.4
Complete destruction of parenchyma	3	4.6

This interval is taken as a basis in this instance, because in a great many cases the onset of symptoms of myxedema was so gradual and insidious that the patient was unable to give any definite time of onset of the symptoms of hypothyroidism.

At the time of operation, each surgeon estimates the amount of thyroid tissue remaining on either side of the trachea in terms of a simple fraction of a normal-sized thyroid lobe. Consideration of these estimations of the amount of thyroid tissue left at the time of operation showed that in cases in which appreciable thyroiditis was not present an average of 0.27 of a normal-sized lobe was left on either side. When definite thyroiditis was present, an average of 0.31 of a normal-sized lobe was left bilaterally. When the thyroiditis was moderate in severity, the amount left was 0.3 of a normal-sized lobe; when the thyroiditis was severe, 0.35 was left, and in extreme thyroiditis, the estimated amount left was 0.36 of a normal-sized lobe on either side. Thus, in this series it is seen that in the cases without appreciable thyroiditis in which postoperative myxedema developed, more tissue was removed, as an average, than in those in which thyroiditis was present.

Another series of 100 cases of exophthalmic goiter was studied histologically and it was found that in only 28 per cent of the cases was there an appreciable amount of thyroiditis present. This contrasts rather

sharply with the incidence of thyroiditis in this series (71 per cent). In this smaller series there was a 2 per cent incidence of postoperative myxedema. Marked thyroiditis was present in both of these cases at the time of operation.

The suggestion that exhaustion may be a causative factor in the production of nonspecific thyroiditis is not borne out by the duration of the symptoms of thyrotoxicosis before operation in this series of cases. In those cases in which no appreciable thyroiditis was present at the time of operation, the average duration of the disease was 24.5 months, while in those cases in which thyroiditis was present, the average duration of the disease was 20.2 months. This finding, however, does not concur with that of Magee, who, in a much larger series of cases of thyroiditis, found that patients with exophthalmic goiter and thyroiditis are hyperthyroid for a longer period before coming for consultation than patients with exophthalmic goiter without thyroiditis. In regard to the duration of preoperative administration of iodine, in those cases without thyroiditis the average period of administration of Lugol's solution before operation was 12.6 days, while in cases with thyroiditis the average was 18.2 days.

That clinical postoperative myxedema is not an irreversible state is demonstrated by two cases in which there occurred recurrent symptoms of exophthalmic goiter, in each case, two years after the patient had been found to have clinical myxedema. In one case, marked thyroiditis was present at the time of operation previous to the onset of myxedema, while in the other, only a few lymphocytes were present. Similar cases have been reported by Haines and by Pemberton. In two other cases there had been present definite clinical myxedema previous to the onset of the symptoms of hyperthyroidism for which operation was performed. In one of these cases there was an adenomatous goiter with hyperthyroidism and at the time of operation definite thyroiditis was present. In the other, a hypertrophic parenchymatous thyroid, no thyroiditis was demonstrated.

In computing the average basal metabolic rate of patients before preoperative administration of iodine had been started, it was found that in cases in which there was no appreciable thyroiditis present the original basal metabolic rate was +45.3. In those cases in which there was appreciable thyroiditis the average basal metabolic rate was +37.9. On subdividing the cases in which there was thyroiditis, it was found that in cases of moderate severity the basal metabolic rate was +42.1; in cases of severe thyroiditis the rate was +37.8, and in cases of extreme thyroiditis the rate was +8.8.

In cases in which thyroiditis was found, the operative wounds drained an average of 2.5 days longer than in those cases in which there was no demonstrable thyroiditis.

In this series the incidence of postoperative myxedema was in a ratio of 1.8 in women to 1 in men. In all cases the incidence of goiter is

usually much higher in women. At the Mayo Clinic the ratio was 2.8 in women to 1 in men in the years 1937 and 1938.

In this series the average age of patients at the time of thyroidectomy was 41.5 years. In those cases in which there was no demonstrable thyroiditis at the time of operation, the average age was 43.9 years, and in those in which thyroiditis was present, the average age was 40.5 years.

SUMMARY AND CONCLUSIONS

In this series an average rate of occurrence of postoperative myxedema in over 15,000 thyroidectomies was found to be 1.2 per cent. Postoperative myxedema is much more frequent in cases of exophthalmic goiter than in those of adenomatous goiter.

Definite thyroiditis was found in 71 per cent of the cases in which thyroidectomy was performed and in which myxedema developed later.

In those cases of postoperative myxedema in which appreciable thyroiditis was not present, the estimated amount of glandular tissue left at the time of operation was found to be approximately 0.27 of a normal lobe on either side, while in cases of thyroiditis the amount left was approximately 0.31 of a normal lobe on either side.

In this series the interval which elapsed between the time of operation and the return of the patient with postoperative myxedema varies inversely, as does the amount of thyroiditis present at the time of operation.

In this series the average basal metabolic rates of patients before the preoperative administration of iodine varies inversely, as does the amount of thyroiditis present at the time of operation.

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Wehner, Kunsemüller, and Biebl perhaps belong to this group. Meyer classified this group as "combination tumors."

2. That although the two components are of different origin, one was responsible for the appearance of the second part of the dual tumor. This possibility includes, therefore, the presence of a carcinoma first and the subsequent appearance of a sarcoma, and the reverse situation, with the sarcoma primary and the carcinoma appearing later. These are the "composition tumors" of Meyer. The experimental work of Ehrlich and Apolant and of Nicholson would tend to offer some evidence that this situation may occur. Ehrlich and Apolant advanced two suggestions to account for the appearance of sarcoma in their transplanted carcinoma. A change in the chemical metabolism of the carcinomatous cells may have occurred and this product may have incited the growth of the sarcoma. The second suggestion was that connective tissue elements had been also continuously transplanted and that because of this process they had finally become malignant. It has been shown, however, that the latter suggestion is erroneous, since transplanted connective tissue will degenerate, and the carcinoma derives its new stroma from the host.

Dorsch, Takano, and Kreibig (Case 2) have reported cases in which the carcinoma was thought to have appeared first with the subsequent production of a sarcoma. Kreibig's patient had had an adenocarcinoma of the breast removed one and one-fourth years before the second operation. At the latter time, a recurrent lesion composed of adenocarcinoma and spindle-cell sarcoma with giant cells was removed.

The cases of Kerbirion and Danel, of Coenen, of Wilensky, and of Kreibig (Case 1) fall into the other category, in which the sarcoma seemed to be primary. It is of interest to note that occasionally, as in Coenen's case, a fibroadenoma had existed for some time with sarcomatous development in this benign tumor. Stimulation of the epithelial cells by the sarcomatous focus may cause a second malignant deviation in the fibroadenoma.

3. That the dual tumor arose from different components simultaneously, perhaps uniting to various degrees. This group comprises Meyer's collision tumors. Schlagenhaufer, Kettle, and Curphey have reported cases within this group. Owing to the anatomic relationship in the breast where the two neoplasms were entirely separate, Curphey justified his conclusion that two entirely different malignant lesions were present and arose independently.

The malignant connective tissue elements which may be found in these complex tumors include cartilage, bone, and myxomatous tissue. Many show numbers of giant cells upon microscopic examination. Metastasis of one or the other or both components to the regional lymph nodes has also been noted.

A MIXED TUMOR (CARCINOSARCOMA) OF THE BREAST*

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CARCINOSARCOMAS of the breast, although they have been reported only in limited number, have aroused particular concern because of the difficulties involved in their classification. Used in its broad sense, the term, carcinosarcoma, is indefinite, and the question whether these neoplasms are carcinomas, sarcomas, or both is often left unanswered. A variety of names, in addition to carcinosarcoma, have been suggested for this dual tumor, and some of them take the descriptive portion of the combined term from the portion of the malignant lesion present first.

In regard to the etiology of these combined tumors, certain experimental work may help to illuminate the situation. Ehrlich and Apolant found that, while they were transplanting carcinoma of the breast in mice, a different histologic picture suddenly appeared in the tenth generation, for a mixed tumor containing malignant epithelial and connective tissue elements was present. It is of further interest, perhaps, to note that the carcinomatous element had almost completely disappeared by the fourteenth generation. Russell also reported that during the continued propagation of a hemorrhagic adenocarcinoma of the mamma of a mouse, a gradual change in character of the stroma from normal connective tissue cells to malignant cells took place. About fifty-five days was the usual length of time required for this transition, once the phenomenon had been observed in this series. The sarcomatous change having been initiated, it tended toward elimination of the carcinomatous structure and the eventual production of pure sarcoma. Nicholson reported an isolated instance of the development of a small carcinoma in association with a transplanted sarcoma in the rat. He concluded that the observation is a rare one and not previously observed.

From the evidence in experimental work and from a careful review of published cases, it is apparent that the conception of the histogenesis of these tumors is somewhat varied. However, certain possibilities concerning their origin may be postulated:

1. That they spring from one original cell and therefore must belong to the true mixed tumors or teratomas. The cases of Harbitz, Hedrén,

*Abridgment of portion of thesis submitted by Dr. Miller to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

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Received for publication, July 3, 1939.

nant teratomas; (2) carcinoma with secondary sarcoma; (3) sarcoma with secondary carcinoma; (4) carcinoma and sarcoma; this would indicate that two entirely separate tumors were present.

REPORT OF CASE

A neoplasm of this dual type was recently studied at the Mayo Clinic. A 50-year-old white married woman reported that for three weeks she had noticed a lump in her left breast. "Twinges" of pain had been present, but she had not noted other symptoms. The tumor had not increased in size and she had not lost weight.

The patient was obese. In her left breast a firm, freely movable, discrete, nontender nodule was found in the upper outer quadrant. There was no change in the skin overlying the tumor, the nipple was not retracted, and the axillary lymph nodes were not enlarged. The heart, lungs, and blood pressure were considered normal. A ventral hernia and some hemorrhoids were also found upon physical examination. The results of routine laboratory examinations of the blood and a roentgenogram of the chest were reported to be normal.

The tumor was removed as a whole, and, after immediate microscopic sections were studied, a radical amputation of the breast was performed. An uncomplicated convalescence was enjoyed and one course of radiotherapy was administered upon the patient's discharge from the hospital. After being advised to have a second course in one month, she was dismissed.

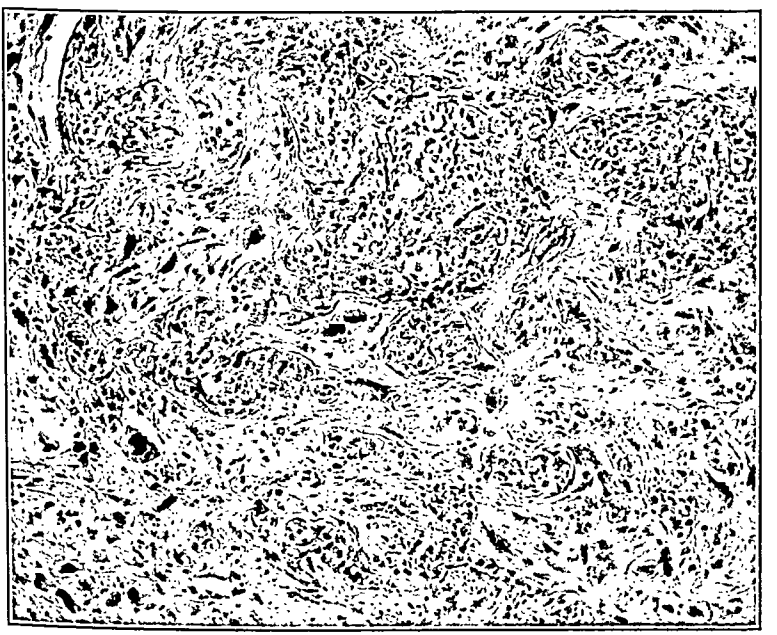


Fig. 1.—Foci of adenocarcinoma in a stroma of sarcoma (×250).

Microscopic study of the removed tumor, which measured 2 by 2 cm., revealed that two types of malignant change were present. Under low power, the outstanding character of the section was the presence of many huge tumor giant cells (Fig. 1). These contained many mitotic figures, both normal and abnormal. The cells were scattered about in a loose stroma which was richly supplied with thin-walled blood vessels. In one portion of the slide, the appearance was that of solid cords of malignant cells arranged in formations suggestive of adenocarcinoma (Fig. 2).

Pasternack and Wirth have reported details of an interesting malignant lesion to which they have applied the name, adenoma acanthoma sarcomatodes. Portions of adenocarcinoma, epidermoid carcinoma with pearl formation, and sarcoma were found upon microscopic study. Pasternack and Wirth concluded that the sarcomatous process was secondary to the acanthoma.

The gross anatomic picture of these combined tumors is multiplex. They may resemble pure sarcoma in one portion and in an adjoining portion look like carcinoma. The zone between them reveals a mixed type of growth. Because of the small number of cases which have been reported, it is without value to ascribe characteristics or peculiarities to this group of neoplasms.

A number of terms have been used to designate these new growths of the breast, and in some the terminology has been derived from the etiologic conception of the author.

The term carcinosarcomatodes has been employed to designate that group in which the epithelial portion of the malignant lesion seemed to have been present first. The tumor arising through the opposite process would thus be called a sarcocarcinomatodes.

Carcinosarcoma, employed by many authors as an all-inclusive term, was used by Wilensky to designate a sarcoma in which carcinoma subsequently developed. If the latter had been the first malignant lesion thought to have been present and a sarcoma had developed later, a sarcocarcinoma would have been present. Fischer-Wasels suggested that carcinosarcoma is a misnomer inasmuch as the malignant epithelial and connective tissue elements in this instance must necessarily arise from one cell.

The demand has been made that the term, carcinosarcoma, if used in its proper sense, be reserved for those neoplasms in which both the carcinoma and sarcoma arose from a common tumor cell. These cells must possess extraordinary lability because of their embryonic failure to differentiate. It would seem with such complex tumors, in which the appearance of either of the components could not be ascribed to the other which was present previously, that they could be more reasonably considered as mixed growths or teratomas.

Carcinomasarcomatoides has been used as a name for a mixed tumor of carcinomatous parenchyma and sarcomatous stroma. No hint as to origin is given in the term.

The term "carcinoma and sarcoma" has been employed where two separate tumors have existed in the breast. There may be little or no anatomic connection between them.

Because of this confusion in nomenclature, it would be much better, depending upon the author's conception of the tumor that he is describing, to designate these tumors as: (1) Mixed growths or malig-

were present. These were nearly all very malignant in appearance, with huge nucleoli and mitotic figures, the latter assuming varied and bizarre shapes (Fig. 3). The stroma was loose and contained scattered red blood cells, polymorphonuclear leucocytes, and lymphocytes.

The two malignant lesions intermingled, with the sarcomatous cells between the cords of adenocarcinoma. The former were present in greater abundance. Involvement of the axillary lymph nodes by either malignant lesion was not present.

Seven and one-half months after her first admission, this patient was re-examined and no indication of a recurrence could be found. A roentgenogram of her chest was again reported to be normal.

Because of the brief history, the small size of the tumor, the intermingled type of growth, and the fact that neither one of the constituents could be demonstrated to have been present first, this tumor perhaps should be placed in the mixed tumor class.

SUMMARY

The etiology of these dual tumors of the breast is briefly discussed. A discussion of the terminology of the "carcinosarcoma" group of neoplasms is included. A mixed growth of carcinoma and sarcoma is reported.

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Under the oil immersion lens, the carcinomatous portion was seen to consist of large pale malignant cells with dark nuclei, pale cytoplasm, and definite intracellular boundaries. No definite acini were seen, which was in keeping with the high degree of malignancy.

The sarcomatous portions were composed of huge cells with the general characteristics of the spindle-cell type. Many giant cells of the uni- and multinucleated type

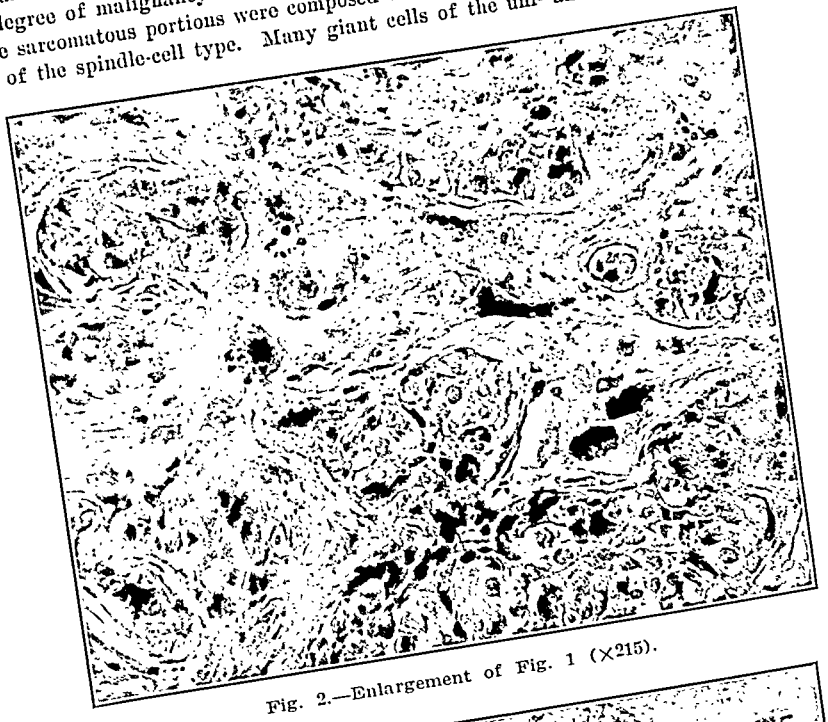


Fig. 2.—Enlargement of Fig. 1 (×215).

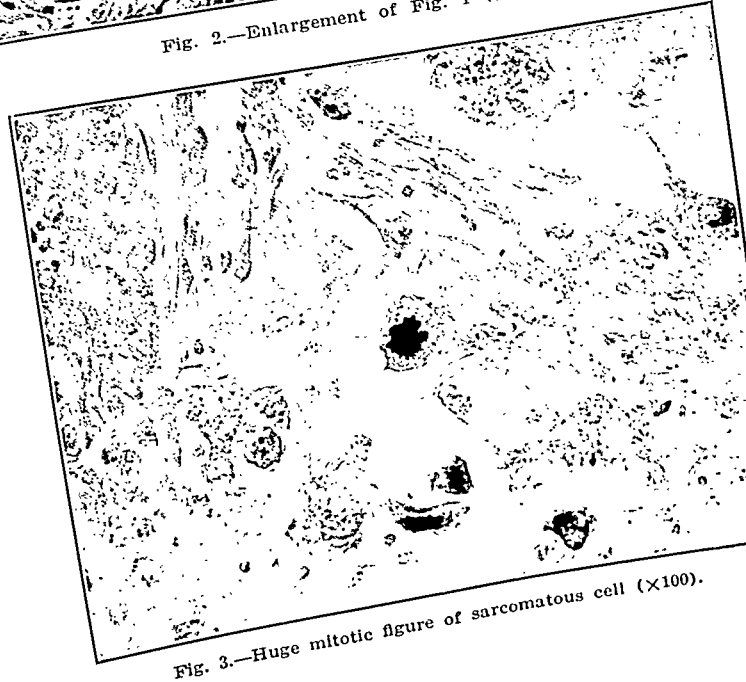


Fig. 3.—Huge mitotic figure of sarcomatous cell (×100).

FIBROSARCOMA OF THE MAMMARY GLAND*

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"PURE" fibrosarcomas or spindle-cell sarcomas are being found to be more infrequent since it is being realized that the great majority of the sarcomas of the breast have their origin in adenofibromas and are therefore more correctly termed adenofibrosarcoma. Ewing wrote: "When one excludes from the group of mammary sarcomas, the adenosarcomas, the malignant forms of mixed tumor containing cartilage, bone, mucoid or fat tissue and certain malignant round, spindle- and giant-cell alveolar pseudo-sarcomas, which are really atypical carcinomas, there is little remaining of a once formidable group of neoplasms."

The incidence of fibrosarcoma of the breast as reported by several authors has varied considerably, as shown in Table I.

TABLE I

INCIDENCE OF FIBROSARCOMA OF THE BREAST

AUTHOR	YEAR	TOTAL CASES SARCOMA	FIBROSARCOMA	
			NO.	PER CENT
Gross	1887	156		68
Gebele	1901	34	11	32
Finsterer	1907	40	10	25
Geist and Wilensky	1915	22	5	23
		435*	136	31
Fox	1934	60	42	70

*Total collected cases.

It is impossible to compare the statistics in this study with the ones cited, inasmuch as changing pathologic conceptions have sharpened the criteria for diagnosis of these tumors. Grossly, the true sarcomas of the breast have a sameness of appearance in the early stages of their development. The majority are rather well encapsulated, round, irregular, or slightly lobulated, and lie in or next to the glandular structure. At an early stage they are not attached to the skin or the deep tissues, and, consequently, can be rather easily "shelled out" in many instances. Pure sarcoma reaches a huge size only infrequently, in distinct contrast to the malignant lesions which originate in the fibroepithelial neoplasms. On cross section, the new growth varies

*Abridgment of portion of thesis submitted by Dr. Miller to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

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Received for publication, July 3, 1939.

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TABLE II

PATIENTS SUFFERING FROM FIBROSARCOMA OF THE MAMMARY GLAND ON WHOM OPERATIVE PROCEDURES HAD NOT BEEN PERFORMED BEFORE THEY CAME TO THE MAYO CLINIC

YEARS WELL	PATHOLOGIC GRADE OF LESION	END RESULT
17	I*	Death from hypertension
Not traced	II*	–
Not traced	II†	–
–	II	Death, postoperative pulmonary embolus
4	IV	Well at present

*Myxomatous change present.
†Tumor giant cells present.

Clinic, while rapid growth of the tumor was noted in these and an additional patient. Three complained of pain in the mammary gland. Radiographs of the chest were normal in the four cases studied. The pathologic grade of the lesion and the end results are shown in Table II. The regional lymph nodes were not involved in any of the cases.

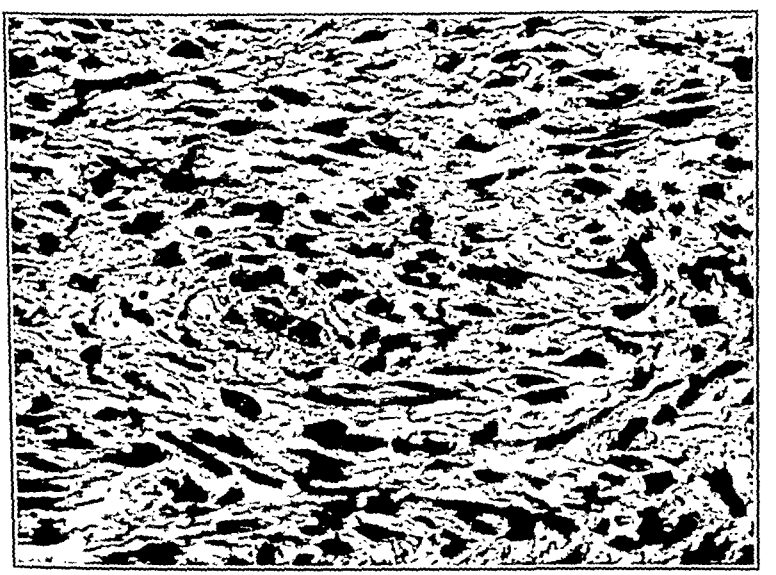


Fig. 2.—Enlargement of Fig. 1. Note spindle shape of cellular elements and occasional mitoses (×420).

Four married women, who had had a previous operation for the malignant lesion for which they came to the Clinic, were seen, and ranged from 32 to 57 years of age. It is significant that these women who had a recurrence were, as a whole, much younger than the group aforementioned All were subjected to operation again at the Clinic. The regional lymph nodes were not involved by the malignant process in any of the patients. End results of treatment are shown in Table III.

It is essential to differentiate between pure fibrosarcoma and adenofibrosarcoma as the cause and prognosis of each are widely different.

from a gray-white to a gray-red, is of moderately firm consistency, and is usually well demarcated from the breast tissue, perhaps being surrounded by a layer of atrophic ducts and acini.

On microscopic study (Figs. 1 and 2), numbers of fusiform cells are seen lying in close apposition and forming strands that run in different directions, frequently interlacing. Cut in transverse section, these spindle-cell elements are small and round and possess a nucleus which almost fills the cell body. On longitudinal view, the nucleus is relatively large and ovoid and has a well-defined network of chromatin. Mitotic figures are present in varied amount, depending upon the grade of malignancy, while blood vessels may be relatively frequent.

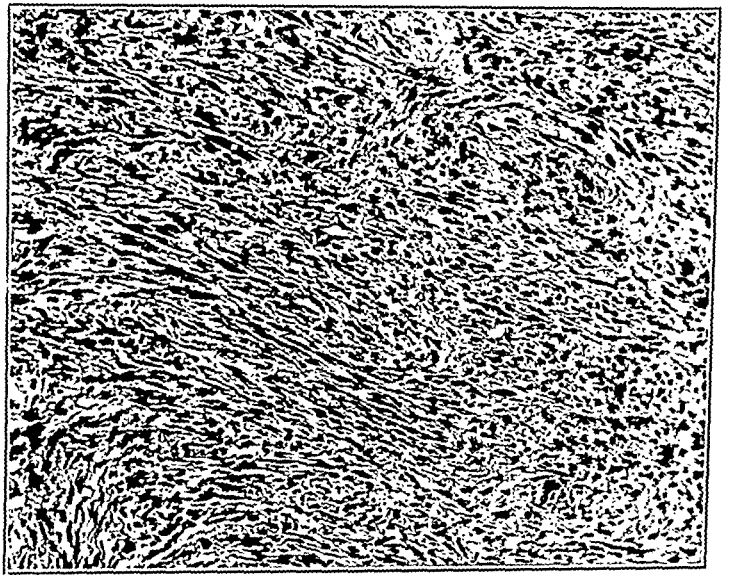


Fig. 1.—Pure fibrosarcoma of the mammary gland (×150).

The regular arrangement of the neoplastic cellular elements about the blood vessels in some of these tumors has caused a few of the earlier authors to err and consider them to be angiosarcoma or perithelioma. Numerous giant cells, which may be either of the tumor or foreign-body type, occasionally are found in these fibrosarcomas. A small amount of fibrillated matrix is found between the cells.

In the years 1911 to 1937 inclusive, nine patients with fibrosarcoma of the mammary gland have been seen at the Mayo Clinic. This number stands in sharp contrast to the twenty-four patients with adenofibrosarcoma which had its origin in adenofibroma. Five patients with fibrosarcoma were seen before being subjected to operative procedure elsewhere. All of these patients were women ranging in age from 44 to 69 years, the average being 49.8 years. Two of these women had noted a mass in the breast for long periods before coming to the

PAINFUL DIVIDED NAVICULAR OF THE FOOT
ITS DIAGNOSIS AND TREATMENT

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PAINFUL divided navicular bones of the foot are common enough so that every practitioner will meet with them several times in the course of his career. So rare is the literature on this condition that the anomaly remains practically unknown, and the affection is labeled usually as ankle sprain, fracture of the navicular, or arthritis.

In a review of the roentgenograms of the feet in 200 unselected individuals, divided navicular bones were found in eight people, or in 4 per cent. Every one of these eight gave histories of sprains or fractures of the foot and indicated the site of the divided navicular as the site of pain. Five of the eight came to us, in a general practice, precisely because of the painful feet. In three of the five, previous x-rays had been taken. Two had been interpreted by general practitioners and one by a radiologist as fractures of the navicular.

So little is generally known of the divided navicular because only two references are to be found in the literature, one by Dwight[1] in 1907 and one by Anspach and Wright[2] in 1937. Its adequate treatment has never been described.

The divided navicular bone, or true tibiale externum, as it has been called (Dwight), develops as an ossification center of the navicular, which, instead of uniting normally with the body of the navicular, makes an independent development as an extra ossicle. It really represents the isolated tubercle of the navicular and is not the small sesamoid often seen in the same region and termed tibiale externum (Dwight). The divided navicular is located at the insertion of the tendon of the tibiale posticus muscle and is firmly fixed in position by the tendon.

The diagnosis of painful divided navicular can be safely made on these points:

1. There is an unusual prominence of the mesial portion of the foot produced by the divided navicular. Tenderness is well localized over and just behind the prominence.

2. On the roentgenogram the smooth contour and texture between the navicular and its divided tubercle mark it as a divided navicular rather than a fracture.

3. Fracture is further excluded by the presence of a similar fragment in the other foot. Divided navicular is a bilaterally occurring anomaly.

The treatment is at first conservative, and, depending on the severity of the pain, bed rest with hot applications or the application of a plaster cast may be resorted to. Frequently however these measures

Received for publication, July 3, 1939.

TABLE III

PATIENTS SUFFERING FROM FIBROSARCOMA OF THE MAMMARY GLAND WHO HAD HAD A PREVIOUS OPERATION BEFORE COMING TO THE MAYO CLINIC

YEARS WELL	PATHOLOGIC GRADE OF LESION	END RESULT
–	IV*	Death from recurrence in 1 yr.
24	I	Well at present
Not traced	I	–
9	IV†	Well at present

*Tumor giant cells present.
†Tumor and foreign-body giant cells present.

In the latter category the epithelial elements have remained active and dilatation of the ducts and acini has resulted in cystic formations of varying size. Usually the history given by a patient with such a neoplasm is that a mass has been present in the breast for a long time, perhaps years, and that it suddenly has increased in size quite rapidly. Such neoplasms are irregular, large, and lobulated and frequently are complicated by hemorrhage, necrosis, and ulceration. From its initiation, the growth has a tendency to be somewhat circumscribed, and, even though it may become large, it still retains this characteristic. In addition it may be freely movable upon the chest wall. The end results of surgical treatment in this group are much better than they are in pure fibrosarcoma. However, a statistical comparison of this group with patients having "pure" fibrosarcoma will not be attempted owing to the small number of the latter.

SUMMARY

Compared to the incidence of adenofibrosarcoma, that of pure fibrosarcoma (spindle-cell sarcoma) is relatively low. The two types must be differentiated for the history is widely different and the prognosis is much better in adenofibrosarcoma.

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The small bone was then excised and the pain immediately disappeared and walking was allowed after ten days. The structure and relation of the bone to the navicular were similar to those in Case 1.

CASE 3.—S. J., male, aged 20 years, laborer, turned his left foot while walking over uneven ground and immediately experienced a severe pain over the medial aspect of the foot and ankle. An immediate x-ray of the foot revealed a divided navicular. After five weeks of rest, massage, and passive motion, walking was still impossible and tenderness directly over the small bone was as intense as ever. Again excision quickly relieved pain and restored function.

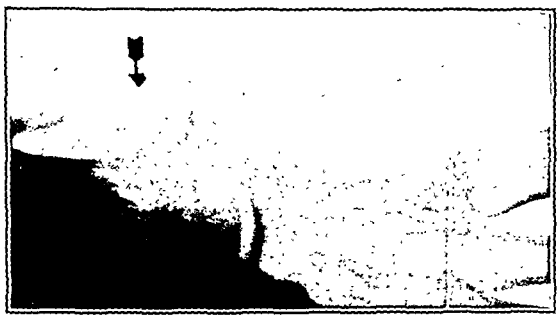


Fig. 2.—Case 2, 10-year-old girl. Divided navicular clearly shown.

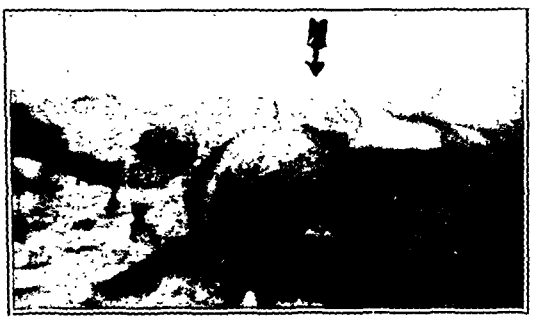


Fig. 3.—Case 3. The divided navicular shows more separation than in the other two cases.

The tibiale externum of each of these three cases was located at the insertion of the tendon of the tibiale posticus muscle and was fixed in position to the navicular by dense tough fibrous tissue. In each case it produced a well-marked prominence on the surface of the foot and this in part may expose it to injury. The adjacent surfaces of the navicular and tibiale externum were smooth and flattened or faceted as though they were surfaces of a joint. Motion in the spaces between them could not be detected under the fluoroscope. The smooth contour and linear margin of density on the opposing surfaces should ward off a diagnosis of fracture of the navicular, and yet this is apparently apt to be made by the inexperienced.

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are inadequate and the pain continues after the cast is removed or motion is resumed. The most adequate treatment and the one resorted to in three of our cases is simple excision of the fragment. The fragment is easily accessible; its removal neither interferes with the function of the tendon in which it is embedded nor are any joint spaces opened. After excision the foot is firmly bandaged and motion contraindicated for ten days. Thereafter the individual may assume his regular duties and does so with an entire absence of pain.

CASE REPORTS

CASE 1.—G. Y., female, 43 years of age, housekeeper, turned her right foot forcibly in stepping from an automobile. There was no external evidence of injury, but the medial ankle and particularly a point just behind the navicular were extremely painful to pressure. A diagnosis of sprained ankle was made and a physician applied strapping. However, after two weeks the foot was still too painful to allow walking and an x-ray was taken which showed what the physician interpreted as a fracture of the navicular. A cast was applied, but after three weeks tenderness was still present, well localized over the supposed fragment which



Fig. 1.—Case 1. The divided navicular is clearly shown in both the anteroposterior and lateral views.

failed to show signs of union. On consultation a diagnosis of tibiale externum was made. The small bone was removed in the office. It was found to be very closely united to the navicular in a dense tough fibrous union but definitely separate from it and presenting a flat, faceted surface to the navicular. The foot was immobilized for ten days. Pain immediately disappeared and after ten days walking was begun without pain. After two years no further evidence of pain has been noted.

CASE 2.—J. J., female, aged 10 years, was seen Oct. 29, 1936. In July she had twisted her ankle while running and had a pain over the medial dorsum of the right foot. This was fairly severe but disappeared after a week. In August the pain returned in the same spot, this time without known trauma. This was treated for a time by a physician as a sprain. The pain became worse until the child was unable to walk. Passive motion of the foot was without pain. However, standing on the foot was very painful and there was an area of well-localized tenderness corresponding to what on x-ray was seen to be a true tibiale externum or divided navicular. No redness or swelling was apparent. The sedimentation rate, Schilling, and general physical findings were normal. Conservative treatment, consisting of absolute rest, massage, and diathermy, resulted in no improvement after four weeks.

Animal experiments have proved the hepatorenal relationship as observed clinically. After severe liver trauma, the same type of changes in the liver and kidneys, blood chemistry, and urine have been described. It must be noted that all animals and all patients receiving traumatic liver injury do not develop evidence of the syndrome. This fact makes an explanation of the syndrome more difficult.

From the evidence which has been presented we may safely conclude that there is a hepatorenal relationship when the liver is damaged by disease or injury, but the explanation of the causative factor or factors and the mechanism of their action upon the liver and kidneys must be determined by future investigation.

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Editorial

Is There a Hepatorenal Syndrome?

SOME doubt has been expressed concerning the existence of a hepatorenal syndrome. Whether or not there is a direct cause-and-effect relationship between diseases of the liver and kidneys may be open to some question. There can, however, be no question about the existence of a relationship, although the possibility of a single etiologic factor producing the disease in both organs must be admitted. It has been suggested, but not proved, that a soluble substance may be elaborated by damaged liver tissue which has a direct toxic effect upon the kidneys.

In a study of so-called "liver deaths" following operations upon the biliary tract, definite pathologic changes have been found in both liver and kidneys. A retention of nitrogen products and a decrease in the urinary output or a complete suppression of urine have been observed. Albumin, casts, pus, and red cells have appeared in the urine. In some of the cases recorded, a bleeding tendency developed which was evident clinically by bleeding from the mucous membranes. At autopsy blood was found in the serous cavities and hemorrhages were often observed in parenchymatous organs and the mucosa of the alimentary tract.

The results of extensive liver trauma present rather convincing evidence that there is a definite cause-and-effect relationship between the damaged liver and functional and morphologic alterations in the kidneys. There have appeared in the literature a number of case reports which present this evidence.[1] Within a few hours after a severe crushing injury or laceration of the liver, changes in the blood chemistry may rapidly develop with an increase in the nonprotein nitrogen and creatinine. Coincident with these changes there is a decrease in the output of urine with the appearance of albumin, casts, pus, and red blood cells. A study of autopsy specimens of the liver and kidneys shows degenerative changes in both organs. In the kidneys the degeneration is chiefly confined to the epithelium of the convoluted tubules and loops of Henle. These changes occur so rapidly and are so definite that the assumption is reasonable that a toxic substance is elaborated by liver trauma which produces a direct effect upon the kidney epithelium. It must be admitted, however, that the toxic effect may not be direct, but due, as suggested by Boyce and McFetridge,[2] to excessive work placed upon the kidney in an effort to excrete damaged liver products.

as the incidence of sequelae in the central nervous system. Frazier[39] discussed definite neurological complications which may follow spinal anesthesia. Because others have experienced such sequelae, these complications are being summarized at this time and a case presented.

The nervous sequelae of spinal anesthesia may be immediate or remote, localized, due to trauma at the site of puncture, or more or less widespread when due to damage from the drug used. Probably there is in every case some toxic reaction produced in nervous tissue by the agents used for spinal anesthesia, but in the majority of cases repair of this damaged tissue is apparently rapid and complete. Occasionally, due to some local or general condition of the patient, recovery is retarded or impeded and therefore we have a few, but widely varied, neurological sequelae which may be temporary or permanent.

CLINICAL SEQUELAE

Headache.—Headache is one of the most frequent complications of either lumbar puncture or spinal anesthesia. Table I presents the number of cases of headache reported by several authors following spinal anesthesia. From these reports, the incidence of headache ranges from 0.1 to 83 per cent. The majority fall within the range of 1 to 25 per cent, comparable to that following simple lumbar puncture.

TABLE I

HEADACHE FOLLOWING SPINAL ANESTHESIA

AUTHOR	TOTAL CASES	% WITH HEADACHE
Albarron	135	1.5
Beurmer	201	4.9
Chaput	800	0.25
Dax	1,500	4.0
Jones	1,000	0.1
Korte	1,800	0.9
Koster	11,000	5.0
Kronig	1,200	1.0
Legnen	350	1.2
McElligott	500	0.2
Neugebauer	18	83.0
Orkin	45,966	15.5
Steurnagel	320	4.7
Tendler	200	1.0
Woodbridge	1,381	0.5

The onset of the headache may be very delayed,[8] but usually it appears within twenty-four hours after anesthesia. These headaches are often severe. The usual duration is four to seven days, but they may persist as long as one year. Headaches following spinal anesthesia are similar to those following lumbar puncture and are believed to be due, in the large majority of cases, to the loss of cerebrospinal fluid by seepage from the hole left in the dura.[71] Increase in cerebrospinal fluid pressure and meningeal irritation also are possible causes.[5, 53]

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

NEUROLOGICAL CHANGES FOLLOWING SPINAL ANESTHESIA

REVIEW OF THE LITERATURE AND CASE REPORT

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NEUROLOGICAL changes, although infrequent, may follow either general or spinal anesthesia (Woltman[108] and Babcock[9]). Occasionally spinal anesthesia may be falsely accused of causing neurological disturbances until a careful post-mortem examination absolves the anesthetic, as is illustrated by Pemberton's[84] case report.

Lumbar puncture alone rarely has any serious or prolonged sequelae. Purulent meningitis is a potential complication, but it does not occur if aseptic precautions are taken. Reynolds and Wilson[87] reported three cases of aseptic meningitis following diagnostic lumbar puncture, but such a development is so uncommon as to make its cause uncertain. Various authors (Tendler,[99] MacRobert,[71] Heldt,[45] Peluse,[83] Kennedy,[54] Parker,[82] and Nelson[77]) have described the well-recognized headaches, occasionally associated with nausea and vomiting (Parker[82]), which appear from their reports in about 15 to 25 per cent of the cases. These headaches are attributed to the leakage of cerebrospinal fluid (Nelson,[77] Leriche[65]). By the insertion of small pieces of catgut through the hole in the meninges to prevent fluid leakage, Nelson[77] was able to reduce the incidence of headache following lumbar puncture to 4.9 per cent in 102 patients.

Experimental and clinical evidences of neurological changes following spinal anesthesia have been presented following the use of a wide variety of anesthetic agents. That clinical manifestations of such changes are rather infrequent is suggested by the report of Foss and Schwalm[36] of no such complications in 3,000 cases. Pemberton[84] stated in 1933 that he had never seen a serious complication following small doses of the spinal anesthetic agents used in the Mayo Clinic. Lundy[69] also stated that with the use of sterile procaine hydrochloride administered by the usual technique and in "safe" doses they had never noticed any serious changes in the spinal cord. Hyslop[50] gave 0.5 per cent

We have seen in our clinic 2 cases of convulsions and death in young children following injection of 1 per cent novocain under the scalp for operations upon the brain. The cerebral pathology present makes them unsuitable for comparison with other cases. However, it may be that the patient's sensitivity to novocain alone in any site may be responsible for some of the sudden deaths under spinal anesthesia.

Cranial Nerve Involvement.—Cranial nerve palsies, as postoperative complications, may be seen in patients who have had general or regional as well as intraspinal anesthesia. One case which Woltman[108] cited had a left abducens palsy appearing eleven days after laparotomy under ether anesthesia. This palsy disappeared in seven days. A left third nerve palsy appeared in another patient six days after an appendectomy under gas and ether anesthesia. This patient had at the time a subsiding phlebitis of the left leg.

Cranial nerve involvement may also follow lumbar puncture or spinal anesthesia. Table II presents some of the cranial nerve involvement that has been reported.

Of all the cranial nerves, the sixth is the most frequently paralyzed. Anderson[5] stated that abducens paralysis may occur in from a few minutes to two weeks after intraspinal injection of the drug. It may be accompanied by photophobia and last seven to ten days. Chiene's[24] 30 cases varied in onset from the ninth to the twelfth postoperative day, and the duration was from three weeks to six months. Ashworth's[8] patient completely recovered in eight weeks. One of Hughes'[49] 2 cases lasted seven weeks.

In Rollett and Berard's[88] cases the paralysis lasted one week to four months. They believed these palsies were due to a mild meningitic reaction. Franke[37] mentioned Adams'[2] explanation of abducens paralysis, which also has been reported following lumbar puncture alone (Gabrieljan[40]), as being due to hemorrhage as a result of alternations in the intracranial pressure. Woltman[108] stated that the cause is unknown.

Smith[92] mentioned mild meningeal reactions after spinal anesthesia, at times associated with an ocular palsy. Nystagmus is a common transient phenomenon according to Pallestrini.[81] DeCourcy[29] had a case with nystagmus appearing ten days after a spinal anesthesia and lasting several weeks. Kennedy[54] had one transient diplopia in 470 cases. Disseminated sclerosis was present preoperatively in this patient.

To summarize the data obtained from twenty-five authors (Table II) who have reported extraocular muscle paralyses, it is apparent that this complication may appear in a few minutes to a few weeks following the anesthesia and last for one week to several months.

Hemiplegia.—Hemiplegia has occurred postoperatively after both spinal and general anesthesia and a wide variety of operative procedures. It is difficult to say in any case in which it developed after spinal anesthesia that it was definitely due to the anesthetic agent. Woltman[108]

Nausea and Vomiting.—Nausea and vomiting, either separately or together, occur not infrequently. Jarman[52] reported an incidence of 0.5 per cent and Garside[41] an incidence of 5 per cent in 357 cases. Thirty-three of Tendler's[99] 200 cases vomited within twenty minutes after injection. Fifteen per cent of Jones'[53] 1,000 cases had nausea or vomiting. Neugebauer[78] had 13 out of 18 cases vomit.

Nausea usually occurs within the first fifteen minutes after the injection of the spinal anesthetic and subsides within the first half-hour. This symptom seems to accompany or follow closely the blood pressure reaction. Nausea and vomiting, in our experience, rarely persist after the action of the anesthetic agent has disappeared. Vomiting may be due to morphine, the operative procedure (traction on the bowel or pressure on the stomach), or even the psychic reaction of the patient, as well as the anesthetic drug.

Respiratory Paralysis or Sudden Death.—Of the immediate sequelae, paralysis of the anterior roots of the phrenic and intercostal nerves and failure of the respiratory center are the most striking. Jarman[52] stated that "sudden collapse" occurred in 0.01 per cent of the cases. Buxton[24] reported 8 cases (6 from the foreign literature) in which sudden respiratory failure occurred soon after the injection. All of these were resuscitated, one after artificial respiration had been administered for five hours. Falk[33] had 3 deaths from respiratory failure before the operation was begun. Several authors report respiratory failure or collapse usually occurring soon after injection, sometimes at the close of the operation and sometimes several hours after operation. Kader (see Violet and Fisher[104]) had 8 instances of respiratory arrest in 1,900 cases. Others reporting early respiratory failure or collapse are: Rapaport,[85] 4 cases; Arnheim and Mage,[7] 1 in 497 cases; Violet and Fisher,[104] 3 in 270 cases; Tendler,[99] 1 in 200 cases. Veal and van Werden[103] report 30 immediate fatalities in 33,811 cases. These deaths occurred in the operating room shortly after the spinal anesthetic was given. Jones[53] reported 6 instances of "collapse" in 1,000 cases. Among these he observed 1 case of respiratory failure at the end of operation with death on the fourth day. Brunn[21] reported 1 sudden death during operation, 1 sudden respiratory death sixteen hours postoperatively (no pathologic findings at post-mortem examination); 1 sudden respiratory death twelve hours postoperatively; and 1 on the ninth postoperative day. The last presented at autopsy very marked arteriosclerosis of the brain and numerous intracerebral softenings. Woodbridge[109] had 1 case with complete respiratory paralysis seventeen minutes after injection. The patient was resuscitated. Bodechtel[16] reported a case of convulsions on the third day following spinal anesthesia with death from respiratory paralysis. A hemorrhage in the left parietal region was found at post mortem. Chaput[23] reported 4 cases in which "syncope" occurred.

TABLE III

NEUROLOGICAL CHANGES WITH VARIOUS SPINAL ANESTHETIC AGENTS

AUTHOR	PERIPHERAL NEURITIS AND RADICULITIS	MYELITIS	ENCEPHALO-MYELITIS	TROPHIC CHANGES	HEMI-PLEGIA	CORTICAL SOFTEN-INGS
Aguglia		1				
Arnheim and Mage		1			3	
Ashworth	1	2				
Babcock	1					
Bedeschi		2				
Bergmann	1					
Brenner-Goldschwend						4
Brock, Bell, and Davison	2	2				
Dassen					1	
Devraigne					1	
Flath		1				
Franke		2				
Goldman				1		
Gottschalk	1					
Hesse	1			1		
Hewer	1					
Hohmeier		1				
Hughes		3				
Jones	1					
Legnen		3				
Lindemulder		1	1			
Loeser	5					
MacLachlan			2			
Marjantschick		1				
Michelson		4				
Müller		2				
Neugebauer		4				
Nonne and Demme		2				
Pugh		1				
Sellheim	1					
Shepelman	1	1				
Silva		1				
Smith		1				
Steuernagel		3				
Stout	4					
Sudeck				1		
Tabanelli	1					
Trantenroth	2					
Urban	1	2				
Waitz		1				
Waters	2					
Woodbridge	12				2	
Nygaard			1			

had incontinence and one leg paralyzed and analgesic, the other leg somewhat affected. Nine months later laminectomy showed a fibrous band constricting the lower spinal cord. Improvement followed removal of the band.

Nonne and Demme's[79] case had paralysis of both legs, bowel, and bladder which persisted from the day of operation until death two years later. He had received tutocain spinal anesthesia for a bilateral inguinal herniotomy. Necropsy revealed adhesions between the pia and

TABLE II

CRANIAL NERVE INVOLVEMENT FOLLOWING SPINAL ANESTHESIA
(VARIOUS DRUGS USED)

AUTHOR	TOTAL CASES	6TH	2ND	3RD	4TH	7TH	8TH	12TH	3RD, 4TH AND 6TH	MIXED
Adam		1								
Adams									1	
Angelescu and Tzovaru										1 (8th and 12th)
Ashworth	650	1					2			
Babcock	12,000	5								
Becker										1 (3rd and 6th)
Blatt review of literature		78	2	1	4	2				7
Bodechtel		1								
Borchardt		1								
Brenner-Goldschwend	2,600	6								
Chiene	12,000	30								
Dax		6								
Deetz		1								
Fawcett	2,000								5	
Franz		3								
Gabrieljan	4,000	1								
Gottschalk		1								
Hughes	500	2								
Jacqueau			1							
Kirschner	4,000	3								
Knobloch										1 (6th and 5th)
Korte	1,800			1						
Landow		1								
Lindemulder		1								
Loeser		2								
MacLachlan										1 (ocular)
Orkin	45,966	0.7%								
Roeder					4					
Schepelmann		1								
Sellheim	1,000								9	
Sonnenberg	1,181	3				1		1		1 (5th and 6th)
Strauss										32
Violet and Fisher	Collected								44	12
Woltman		1								
Backer-Gründahl		2								
Nygaard	1,198						1			1 (6th and 7th)

mentions thrombosis, embolism, and unknown causes in discussing the etiology of such hemiplegias. Seven reported cases following spinal anesthesia appear in Table III.

Paraplegia.—Mennell[74] stated that neurologists recognized an entity, "stovain tabes." Neugebauer[78] reported one case of paraplegia. In another series where tropococaine was used in amounts higher than 0.05 c.c. of 5 per cent solution, 10 out of 18 cases had paralysis of the legs lasting several hours. Violet and Fisher's[104] 16 cases were from sixteen authors who used four different agents. In the majority of cases recovery was spontaneous in from five days to five months. One of Steuernagel's[96] 3 cases lasted three months, then recovered. The others were transient. In one case eight days postoperatively neurological changes were noted, especially involving the right leg. Hewer's[47] case

to injection of the drug into a nerve root. Anderson[5] stated that radiculitis may develop and last several months, but eventually recovery occurs.

Backache.—Backache, at least in a mild degree, probably occurs more frequently than is reported because of difficulty in evaluating this complaint. Tendler[99] in 200 cases had 1 instance of severe backache lasting one week. Woodbridge[109] reported 3 instances of backache in 1,381 cases and Jarman[52] stated that backache occurred in 0.02 per cent of the cases after spinal anesthesia.

Myelitis.—Smith[92] observed one complete transverse myelitis in the ninth thoracic segment which appeared on the seventeenth postoperative day. Brock, Bell, and Davison[20] and Arnheim and Mage[7] each reported 1 case of transverse myelitis. Franke[37] observed 2 such cases with permanent paralysis. Orkin[80] gave 0.16 per cent as the incidence of myelitis. Nonne and Demme[79] reported a case following the injection of tutocain. See Table III.

Meningitis and Encephalitis.—The occurrence of infection following spinal anesthesia is perhaps the most easily explained of all the complications and can be prevented by aseptic technique. The etiology of

TABLE IV

MENINGITIS FOLLOWING SPINAL ANESTHESIA

AUTHOR	SEPTIC	ASEPTIC	? TYPE
Arnheim and Mage	1	1	
Ashworth	1		
Bodechtel	1		
Brock, Bell, and Davison		3	
Brunn	1		
Campbell	1	1	
Hyslop			1
Orkin	9		
Rehn	1		
Schepelmann			1
Sonnenberg	3		
Violet and Fisher	1		

the "aseptic" meningeal reactions is not clear. Table IV presents a summary of some reported cases. *B. pyocyaneus* was isolated from Arnheim and Mage's case.[7] Orkin[80] reported an incidence of 0.26 per cent of meningitis and encephalitis. He found 9 cases of septic meningitis in 15,000 collected cases. These 9 and the 1 recorded by Arnheim all ended fatally. Campbell[22] reviewed the histories of 2 patients who developed meningitis. One presented at necropsy a monocytic meningitis with a large intraventricular hemorrhage; the other, acute purulent meningitis, intraventricular hemorrhage, and diffuse ganglion cell degeneration in the cerebral cortex. The organism was undetermined in the latter. The first case had preoperatively multiple small furuncles over the body and an acute cystitis. The second had an abscess of the heel. Brock, Bell, and Davison[20] reported 1 case of polioencephalitis;

the dura mater in the lower part of the spinal canal. There was ascending degeneration of almost all of the posterior columns of the lumbar and sacral cord, but the posterior roots and horns were intact. The brain showed no histopathologic changes. Of Michelson's[75] cases, 2 eventually came to necropsy. Thickened meninges adherent to the spinal cord were found.

Quadriplegia.—Devraigne, Suzor, and Laennec[31] reported a case of quadriplegia. In this case 5 per cent novocain was used. Four days postoperatively the patient developed loss of muscle tone in the legs. On the fifth day a complete flaccid quadriplegia was present. On the eighth postoperative day there was rapid and spontaneous recovery with slight residual impairment of extensor strength in the lower extremities.

Bowel and Bladder Disturbances.—Neugebauer[78] reported 3 cases of temporary anal sphincter paralysis following tropococaine. Waters[106] had 1 such case out of 297 patients. In this case the paralysis lasted twelve days. Beurnier[104] had 1 in 210 cases. Silva[91] saw 1 case with permanent bowel and bladder paralysis after spinal anesthesia for the removal of an inguinal node. Hughes[49] had 3 cases in 500. One had retention for many months, one had loss of bladder power and anal analgesia, and a third was incontinent. Arnheim and Mage[7] had 2 cases out of 497 who had urinary retention. Bedeschi[12] reported paralysis of the anal sphincter in 2 out of 294 cases with amylocaine hydrochloride. One subsided after ten days, the other after thirty-five days. Cystitis and decubitus ulcers developed in the second case.

Neuritis and Sensory Disturbances.—Woodbridge,[109] in a study of 1,381 cases, reported the following: hyperesthesia in 2; numbness in 2; anesthesia of the thigh in 1; and coccygodynia in 1. Paresthesias were reported by Orkin[80] in 0.19 per cent of 45,966 cases; Brock, Bell, and Davison[20] saw 2 cases of cauda equina neuritis. Jones[53] reported 1 case of sciatic pain lasting six months after a spinal anesthesia. Brunning[104] stated that he had several out of 200 cases who had persistent pain in the legs. Waters[106] cited 2 cases out of 297 that had pains in the lower extremities for some time after leaving the hospital.

Sellheim[90] saw 1 instance of radial nerve involvement in 1,000 cases. Lindemulder[66] reported a case of severe pain in the upper extremity. This patient died and changes in the dorsal and lumbar cord were found at necropsy.

Woodbridge[109] had 4 patients with transient foot drop following metycaine spinal anesthesia. Schepelmann[89] had 1 case in which foot drop appeared on the eighth postoperative day and recovered completely in one year. McElligott[73] observed 1 foot drop following 500 scurocaine anesthetics.

Brock, Bell, and Davison[20] saw a case of lumbar radiculitis appearing three weeks after injection of the anesthetic. Babcock[10] had 1 case of violent radiculitis in 12,000 cases. He attributed this complication

were said to have been normal. In another instance where avertin and tropococaine were used, sudden unconsciousness and convulsions developed two days postoperatively. Six days later a paralysis of the left external rectus muscle appeared and the patient died on the sixteenth postoperative day. There were multiple hemorrhages throughout the brain and spinal cord. Bodechtel[16] believes that circulatory changes produced by spinal anesthesia may favor the occurrence of hemorrhage and thrombosis in the central nervous system.

Schepelmann[89] had a patient who was very restless during and after the operation. He became unconscious and remained so for three days and for weeks was irrational and incontinent, with paralyzed sphincter, bladder, and legs. A diagnosis of "myelitis lumbalis" was made. Years later the patient was slightly improved.

Guinard[104] described "syncopes" followed by fever, intense headache, and a meningeal reaction. Ashworth[8] reported an instance of leg pain beginning soon postoperatively and followed one year later with occipital headache. This author also had a case with headache three days postoperatively and later failing eyesight and tingling and numbness of the right leg. He stated that late studies of neurologists showed that 4 of 202 cases after spinal anesthesia had nervous sequelae.

Pemberton[84] discussed a case that developed meningitis following a Mikulicz operation under spinal anesthesia. On the seventh postoperative day manifestations of meningitis appeared, with death on the tenth day. Necropsy revealed acute purulent meningitis limited to the vertex which was probably blood-borne from a small pulmonary abscess which had developed around a small metastatic carcinoma growth. These findings perhaps absolved the spinal anesthetic. He stated that "there is a tendency for the surgeon to attribute to the anesthetic or its mode of administration any unusual complications which cannot readily be accounted for otherwise."

The following case report is made in an effort to add to the records of sequelae that may follow spinal anesthesia. It is necessary, however, to bear in mind the above statement of Pemberton, as we in no way wish to discredit the selective and indicated use of this type of anesthesia.

CASE REPORT

Mrs. V., age 38 years, was a patient who had had a diarrhea of ten to twelve stools daily for six months, a loss of 75 pounds in weight, abdominal cramps, and progressive weakness to the point of inanition. She appeared cachectic and acutely ill. Her blood pressure was 118/58. The cardiovascular system was apparently normal. The lungs were clear. The abdomen on palpation gave a sense of fullness which was neither tympanitic nor ascitic. There was tenderness over the region of the sigmoid and descending colon. The liver was palpable two finger-breadths below the costal margin, smooth and nontender. Her red blood count was 4,450,000; hemoglobin, 65 per cent; and white blood count 18,100, with 76 per cent polymorphonuclear leucocytes, 2 per cent large lymphocytes, and 3 per cent small lymphocytes. The urine contained one plus albumin. The blood Wassermann

Lindemulder,[66] 1 case of encephalomyelitis; Ashworth,[8] 1 nonhemolytic streptococcus meningitis beginning twenty-four hours postoperatively; Schepelmann,[89] 1 case of meningitis which expired four days postoperatively; Violet and Fisher,[104] 1 death of suppurative meningitis eight hours postoperatively; Sonnenberg,[93] 3 cases with septicemia and suppurative meningitis; Rehn,[86] 1 death thirty hours postoperatively of suppurative meningitis; and Brunn,[21] 1 purulent meningitis. The last patient had a septic course before the spinal. Bodechtel's[16] case had meningitis with brain hemorrhage. Reynolds[87] reviewed 3 cases of aseptic meningitis following diagnostic lumbar puncture. The patients had fever, stiff neck, and positive Kernig's sign. All recovered.

MISCELLANEOUS COMPLICATIONS

Hadfield[44] reported a death due to *bronchial spasm* and also one due to *increased dyspnea* in an asthmatic patient after spinal anesthesia. Stillwell[97] had a case of *massive pulmonary collapse.*

Obviously, *hysteria, hallucinations,* and *delirium,* as well as the true *psychoses,* are complex in origin and can never be unquestionably attributed to a spinal anesthesia as their simple cause. In fact, Woltman[108] stated that when a truly "postoperative psychosis" develops it almost invariably follows an inhalation anesthesia, usually including ether. He could not find a single case at the Mayo Clinic of true postoperative psychosis following a spinal anesthesia. Woodbridge[109] included 1 case of hysteria in his review. Munchmeyer[104] had 2 instances of "traumatic hysteria" in 1,000 cases. Reznier[104] saw 1 case of paralysis of the extremities and neck with complete recovery in fifteen days, which he attributed to hysteria. Mingozynini[104] reported "hysterical convulsions" for eight months following a spinal anesthesia. Steuernagel[96] had 1 out of 320 patients develop a psychosis. Orkin[80] gave the incidence of psychosis as 1.8 per cent. Brunning[104] reported 2 in 2,000 cases. It is the general belief that persons with any changes of the central nervous system should not be given a spinal anesthetic.

MIXED COMPLICATIONS

Dandois[25] had a patient develop headache and convulsions after cocaine spinal anesthesia and on the ninth postoperative day a complete paraplegia. Delirium and mania then began and lasted one month. The author questioned this being a meningoencephalitis because of an afebrile course.

Bodechtel[16] reported convulsions three days postoperatively, after a novocain spinal anesthesia, with later facial paralysis, respiratory paralysis, and death. Necropsy revealed a cerebral infarct. There was no examination of the spinal cord. One patient died at the end of an operation performed under tropococaine spinal anesthesia and avertin. Necropsy revealed no cause of death, and the spinal cord and brain

ganglion cells in the central nervous system, changes described by Nissl under the heading of acute disease of the nerve cells. The cell body becomes swollen; the fundamental unformed substance of the cell, the hyaloplasm, stains more deeply with basic solutions and this process extends into the axone and dendrites so that the ramifications of these can be followed for greater distances than normally is the case. The nucleus swells, moves toward the periphery of the cell, and the nucleolus enlarges. The glial elements show both progressive and regressive alterations: progressive indicated by cell division and accumulation of glial nuclei around abnormal nerve cells, the process of neuronophagia; regressive indicated by hyperchromatosis of the glial nuclei. These changes were seen in this case spread diffusely throughout the brain. Examination of four areas of the cerebral cortex, of the thalamus, the lenticular nucleus, the small nuclei in the wall of the third ventricle, and both mammillary bodies revealed this acute, nonspecific disease of the nerve cells, which we have attributed to the patient's extensive systemic infection.

In addition the right mammillary body showed hemorrhagic softenings, multiple small areas in which there was complete destruction of all of the cells, and the presence of only vague cell shadows and accumulations of yellow hematoidin pigment. There were a marked proliferation of capillaries and a profuse overgrowth of glia along with acute disease of the nerve cells in those areas of the mammillary body not occupied by the softenings. Bodechtel[16] has described 1 brain in which there were numerous hemorrhagic infarcts in a patient who died on the second postoperative day following an operation under novocain spinal anaesthesia, and Brenner[19] has described 4 autopsies in which softenings of the brain were found following spinal anesthesia. In the case we are reporting the patient's poor general condition and consequent poor circulation were more than adequate to account for the changes found in the right mammillary body without implicating spinal anesthesia. Since the areas of softening here were several weeks old it is a possibility, but in no way a proven fact, that they might have arisen during the period of somewhat poorer circulation at the time of spinal anesthesia and operation.

We come now to the changes seen in the spinal cord and brain stem. Eight different blocks from the cord were studied, and Nissl, fat, Weil, and Spielmeyer stains for myelin, and Marchi stain, hematoxylin and eosin, and Freeman's silver stain for axis cylinders were used. With the Nissl stain most of the nerve cells in the lumbar cord show the so-called retrograde type of degeneration in varying stages of severity, but usually in an advanced stage. The cells are swollen and rounded; their protoplasmic processes seem to have vanished right up to the cell origins; the Nissl bodies in the cytoplasm have largely or completely disappeared, leaving the cell body with a light blue opaque ground glass appearance. The nucleus is eccentric, may produce a humplike protrusion of the cell membrane, or may be completely extruded. In the thoracic cord scattered cells not only in the anterior horns, but also in Clarke's column and in the intermediolateral cell column show these retrograde changes. But in the cervical cord, the medulla, and the pons, except for marked degeneration in the dorsolateral cell column, the majority of the cells appear normal. In the fat stains large globules of orange-staining lipoid are seen to be present in the degenerated cells. In the stains for myelin the anterior and posterior roots in both their intramedullary and extramedullary portions are seen to be either extensively or completely demyelinated. This change is present in all of the sections. In the lumbar portion of the cord and to a less extent in the thoracic and cervical regions there is a zone of peripheral demyelinization extending inward a variable distance toward the center but present to some extent around the entire 360 degrees of the circumference of the cord. In the demyelinated fibers there is some swelling, but there is no increase in sur-

and Kahn tests were negative. Her temperature ranged between 100 and 104° F. On proctoscopic examination much creamy mucoid material was obtained, and a large rectovaginal fistula was seen. There were no amoebae in the stools. X-ray studies of the gastrointestinal tract indicated a regional ileitis.

The diarrhea was controlled by medication; but the fever and loss of weight continued in spite of blood transfusions and supportive treatment, so resection of the affected bowel was advised. When the patient was brought to the operating room, she appeared pale and cachectic. She looked 50 years old instead of 38, her actual age. She complained that her "chest was too tight" and her mouth dry. She breathed loudly through her mouth and talked in a rambling fashion. She cooperated well, but she did not seem to realize that she was in an operating room or having an operation. Her skin was dry, her tongue coated, and her breath foul. She was coughing and expectorating thick sputum. A chest examination was negative. Her pulse rate was 112 and blood pressure was 110/70. Spinal anesthesia was used; 140 mg. of novocain crystals dissolved in 5 c.c. spinal fluid were injected in the spinal canal at the third lumbar interspace. A 20-gauge Lundy spinal needle was used. Anesthesia to the fourth dorsal level was obtained. At the end of the operation, the patient felt the last few skin stitches. Her condition was good throughout the procedure, which lasted one hour and twenty minutes. Eighteen inches of ileum were removed, and a lateral anastomosis of the ileum and anterior surface of the cecum was made.

Following this operation the patient seemed to be improving slightly up to the ninth day, when she suddenly had a severe chill and temperature elevation to 103° F. Then her condition gradually became worse in spite of many blood transfusions. On the eighteenth postoperative day she complained of difficulty in breathing. A chest examination at this time showed nothing essentially abnormal, but by the next day she was obviously using the accessory muscles of respiration. A diagnosis of paralysis of the diaphragm was made and verified by fluoroscopic examination. A neurological examination showed, also, a flaccid paralysis of both lower extremities with bilateral positive Babinski reflex. She was placed in a Drinker respirator, but there was no improvement, and on the twenty-eighth postoperative day she expired after vomiting and aspirating the vomitus.

Post Mortem Examination.—The weight of the body was 62 pounds. There was obstruction of the trachea and main bronchi by stomach contents and overexpansion of both lungs. A very early bronchopneumonia was found. The right pulmonary artery was thrombosed. The heart was small and showed fibrous thickening of the mitral valve. The esophagus was small, measuring only 2 cm. in circumference.

The terminal ileum was absent with a side-to-side enterocolostomy. There were regional ulcerative ileitis and colitis with a small perforation in the transverse and descending colon. The portal and splenic veins were thrombosed. Cholelithiasis was found with obstruction of the neck of the gall bladder and dilatation of gall bladder with white bile. There was slight fatty degeneration of the liver. There were a large rectovaginal fistula and two ischiorectal abscesses with fistulas. There were marked vaginitis and cervicitis. The bladder was diffusely inflamed and there was an ascending ureteropyelitis with multiple abscesses in both kidneys. There were multiple phleboliths of the veins of the broad ligament. There were an old thrombus in the right iliac vein and recent thrombosis of the left iliac vein.

The only abnormalities in the central nervous system apparent on gross examination were dilated and engorged vessels in the lepto-meninges over the cerebral hemispheres and in the thalamus, and numerous pin-point hemorrhages in the right mammillary body.

In an individual with such severe and extensive systemic infection one expects to find on microscopic examination marked changes in the appearance of the

generation in the anterior horns of the spinal cord but also a demyelinization of the posterior columns and posterior roots, and in one ape and one dog there was a demyelinization around the entire periphery of the cord extending in irregularly toward the center. Klose and Vogt[56] gave dogs and rabbits spinal anesthesia with stovain, novocain, and tropococaine. They found no changes in the ganglion cells from two hours to two days after injection, but subsequently the reaction of degeneration was seen in some of the cells of the anterior and lateral horns of the lumbar and dorsal regions and to a lesser extent in the cervical region.



Fig. 2.—Herxheimer's method for fat (×325). Anterior horn cells in lumbar region. Orange-staining globules of lipoid material in all of the nerve cells (black in the illustration).

The Marchi stain showed fiber degeneration in the entire periphery of the cord and in the posterior columns. Spiller[95] found in a dog killed forty-two days after repeated stovain spinal anesthesias that the lumbar cord showed: (1) degeneration in the posterior columns and in the intramedullary portion of the anterior roots, and (2) swollen axis cylinders in the anterior and posterior roots. Davis and co-workers,[27] using four spinal anesthetic preparations with procaine as their chief constituent, found in dogs: (1) a slight inflammatory reaction in the

rounding glia, and the involved areas have the moth-eaten appearance seen in subacute combined degeneration of the spinal cord. The Freeman stain shows the axis cylinders to be essentially normal.

HISTOLOGIC STUDIES OF THE EFFECTS OF SPINAL ANESTHETIC AGENTS IN ANIMALS

Koster and Kasman[60] found that retrograde degeneration of ganglion cells in the cord and medulla oblongata is produced in frogs by spinal anesthesia with procaine and that these changes begin to regress in three hours. Twenty-four hours after the injection, the frog's spinal cords are again normal.

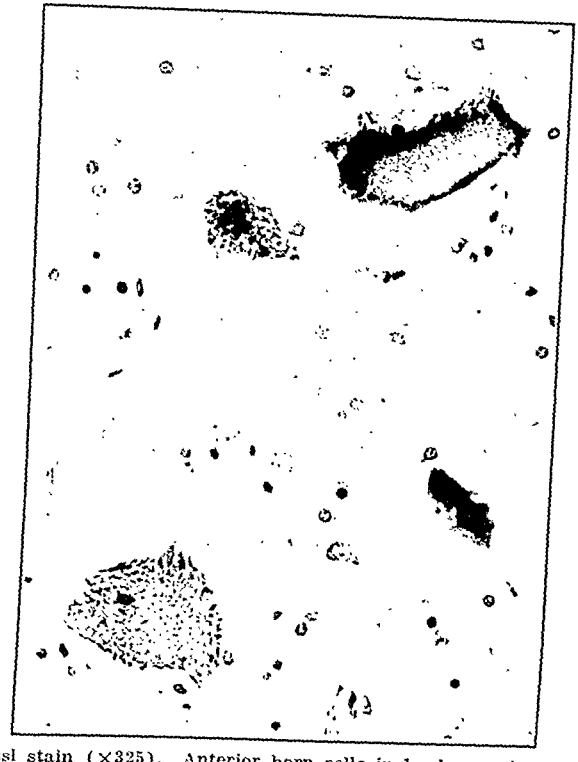


Fig. 1.—Nissl stain (×325). Anterior horn cells in lumbar region. Severe retrograde type of degeneration in cell at upper right; milder degree of same type in cell at lower left.

It has been shown in animal experiments by van Lier[102] (1907) that normal dogs given a subarachnoid injection of stovain show retrograde degeneration in the cells of the lower spinal cord, reaching a maximum by six hours and returning almost completely to normal twenty-four hours after the injection. Wossidlo[110] (1908), using stovain, alypin, and novocain in rabbits, came to essentially the same conclusion. Spielmeyer found in one dog and three apes which had a flaccid paresis of the lower extremities following single or repeated stovain spinal anesthesias that there was not only persistent retrograde ganglion cell de-

3 of these cases[20, 66, 79] there was either a demyelinization of roots and periphery of the cord in the lower spinal canal or retrograde degeneration of ganglion cells or both.

In our case, since the changes in the spinal cord closely parallel those found following spinal anesthesia in animal experiments, and in 3 of the previously reported clinical cases, it is our conclusion that they are primarily caused by the spinal anesthetic, although in this case it also seems likely that the patient's extremely poor general condition made her spinal cord much less resistant to the toxic action of the anesthetic.

SUMMARY

From this report it is obvious that a wide variety of neurological complications, either immediate or remote, may follow spinal anesthesia. The tables summarize the pertinent data. Undoubtedly many complications will go unrecognized unless careful postoperative neurological studies are made. That some of these complications may appear days, weeks, or even months after spinal anesthesia should be of definite interest to internist, surgeon, and anesthetist. Fortunately, these complications are relatively infrequent and should not deter the use of this anesthetic when it is indicated.

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spinal leptomeninges; (2) retrograde degeneration of the anterior horn cells still present in slight degree ninety days after the injection; (3) swelling and fragmentation of axons in the lumbar and sacral regions up to twenty-one days after the injection; and (4) peripheral demyelinization in the lumbar cords twenty and thirty days after injection. Lundy and co-workers[68] in the same experiment obtained the same result in the axons and myelin, but found no meningeal or ganglion cell



Fig. 3.—Spielmeyer's method for myelin (×34). One lateral column and adjoining gray matter in lumbar region. Note zone of peripheral demyelination of varying thickness.

changes. Winograd and Rosenbloom,[107] using spinocaine in dogs, found only early irritative changes (cloudy swelling of ependymal cells) in the spinal cord, with no degenerative changes. Wossidlo[110] believed that there was "no pathologic-anatomic reason to warn against the use of spinal anesthesia."

We have been able to find in the literature 6 clinical cases of late death following spinal anesthesia in which there were symptoms of cord involvement and in which autopsy studies were made.[20, 58, 66, 75, 79] In

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Review of Recent Meetings

REPORT OF THE MEETING OF THE NORTH CENTRAL BRANCH OF THE AMERICAN UROLOGICAL ASSOCIATION, INDIANAPOLIS, IND., SEPT. 25-27, 1939*

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THE North Central Branch of the American Urological Association met at Indianapolis, Ind., on Sept. 25 to 27.

C. C. Higgins, Cleveland, Ohio, discussed present opportunities for training in urology, emphasizing that only the rudiments can be taught to undergraduates because of the demands made upon their time by the other specialties. While relatively few clinics offer really adequate training in urology at present, the number of those that do is increasing. The efforts of the American Board of Urology to catalogue residencies and fellowships and to elevate the standards of training and practice should be of increasing assistance to those seeking training in the future.

J. B. Morgan, Cleveland, Ohio, discussed the indications for pneumopyelography, thus far little used. It is of value chiefly in demonstrating radiotransparent calculi when other methods fail, and in such circumstances it may be invaluable. While there is theoretically some danger of air embolism, Morgan has had no mishaps in a considerable series of cases.

L. P. Dolan, Toledo, Ohio, presented a case of sudden collapse with allergic manifestations and death following the intravenous injection of diodrast. He feels that diodrast and similar agents are contraindicated in any patient with a history of allergy, although there is little mention of such a contraindication in the scientific, and none in the commercial, literature on excretory urography.

N. J. Heckel, Chicago, Ill., employed testosterone propionate in benign hypertrophy of the prostate, undescended testis, and sterility, quite without success. Sperm counts made before, during, and after treatment indicate that testosterone impairs spermatogenesis. In Froelich's syndrome and hypogonadism, testosterone caused a definite growth of the penis and of the pubic hair, and was useful.

J. S. Eisenstadt, Chicago, Ill., operated upon thirteen patients who had received anterior pituitary-like substance for undescended testes. In those who had received a total of more than 6,000 rat units, the testis was smaller and softer than usual, suggesting injury by the hormone, although the evidence of a definite connection between the use of hormone and the size of the testis seems far from clear if one considers how often the undescended organ is not quite normal.

*Only those papers actually heard by the author are reviewed herein.

Received for publication, October 25, 1939.

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Charles D. Ehlert, Alton, Ill., reported a case in which appendicitis produced dysuria, pyuria, and urinary frequency with fever and which was mistaken for pyelonephritis until peritonitis developed and led to a fatal outcome. The more usual error consists in removing a normal appendix for symptoms actually due to ureteral calculus or seminal vesiculitis. While the average case is usually readily diagnosed, the exceptional one may demand great diagnostic acumen.

Ruben Flocks, Iowa City, Ia., discussed some interesting studies of the calcium metabolism in patients with renal lithiasis; in two-thirds of the cases he found an increase in calcium excretion on the affected side whether the calcium content of the diet was low or high. When urine was collected separately from the two kidneys, excretion was usually higher on the affected side. He pointed out that acidification of the urine in cases of increased excretion, while usually desirable postoperatively to prevent recurrence of stones, at times might cause further increase in excretion of calcium and so favor stone formation. In patients whose excretion is normal this does not hold.

Parke G. Smith, Cincinnati, Ohio, described the successful use of ureteroureteral anastomosis. The lower ureter had been demaged at a high enough level so that it could not be reimplanted into the bladder; it was divided above the site of injury, carried across beneath the peritoneum to the other ureter, and anastamosed to it; subsequent urograms showed both kidneys to be normal. **C. C. Higgins,** Cleveland, Ohio, reviewed a similar case of his own. While this is an admirable achievement, one cannot help but wonder whether, under most circumstances, it would not be wiser to implant the affected ureter into the bowel or to remove its kidney, rather than to jeopardize the opposite kidney by meddling with its ureter.

F. E. B. Foley, St. Paul, Minn., presented an interesting example of embolism of the renal artery with the following features; an elderly woman with a cardiac lesion developed sudden severe renal pain. Cystoscopy demonstrated anuria on the affected side but with a normal retrograde pyelogram. Subsequent excretory and retrograde pyelograms at intervals showed a functionless kidney which was still shrinking a year later, thus confirming the diagnosis.

THE SWEDISH SURGICAL SOCIETY

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THE spring meeting of the Swedish Surgical Society was held in the surgical amphitheater of the Academic Hospital, Uppsala, Sweden, on Saturday, May 20, 1939. Before proceeding to a discussion of the meeting, a very brief review of the organization of Swedish surgery will be given for the benefit of American readers.

As in most other countries, the medical schools of Sweden are a strong determining factor in the advance of surgical teaching and practice. There are three separate medical schools in three towns: Lund in the south, Stockholm in the central part, and Uppsala, an hour's train ride north of Stockholm. This ratio of three schools to 6,000,000 inhabitants is much the same (1:2,000,000) as in the United States with 67 schools to 127,000,000 (1:1,800,000). **Petrén** is the

Received for publication, October 26, 1939.

In the ensuing discussion of hormones, **W. E. Lower**, Cleveland, Ohio, spoke very hopefully of the possibilities of endocrine therapy in prostatism, although success is not as yet at hand.

Russell Herrold, Chicago, Ill., reported that sulfapyridine had cured 75 per cent of the cases of gonorrhea treated by him in from five to seven days; 15 per cent were cured by a second course, and 10 per cent proved refractory. If this is borne out by subsequent experience, gonorrhea may be regarded as very nearly conquered.

On the second day, **Harry Goldblatt**, Cleveland, Ohio, reviewed his experimental work upon hypertension. In addition to the experimental proof that renal ischemia, even when unilateral, may cause hypertension, clinical evidence is now accumulating. The mechanism by which ischemia produces hypertension is not yet fully known. Goldblatt states that it is only one of a number of factors which may produce high blood pressure, and that its relative importance is not yet known. The reviewer feels that many an innocent kidney will be removed from patients with hypertension before this fact becomes as apparent to urologists and surgeons as it is to Dr. Goldblatt.

W. N. Taylor, Columbus, Ohio, described his experiences with suprapubic prostatectomy and transurethral resection; he was unable to believe that the latter operation was preferable in 90 per cent or more of the cases, as is held by some. In his own hands the mortality of the two operations was not very different. Open operation is easier and more certain in the large prostate, although he remarked that the term "large" meant various things to different urologists.

The paper of **C. R. Marquardt**, Milwaukee, Wis., on 74 cases of injury to the urinary tract by violence may be summarized as follows: In diagnosis excretory urography and cystography are invaluable. In treatment, conservatism and alert observation are the keys to success with renal injury. Surgical drainage to the injured bladder is imperative. The traumatized urethra may respond to catheter drainage, while the ruptured organ must be repaired surgically. In any case, a stricture must be anticipated and dilatations begun very early if stricture is to be avoided.

Ureteral injuries during gynecologic operations were considered by **I. J. Shapiro**, Chicago, Ill., and **George Ewell**, Madison, Wis. If injury is discovered at the time of operation, repair over a catheter is the method of choice, and extraperitoneal drainage is essential. If the lesion is discovered during early convalescence, nephrostomy on the obstructed side is far safer than reopening the abdominal wound. Later, an occluding ligature may be absorbed and continuity restored spontaneously, or the severed ureter may be united end-to-end over a catheter and reimplanted into the bladder or even into the bowel. Successful examples of various methods were supplied, including some in which repair or reimplantation was technically impossible, and in which nephrectomy was the best solution.

On the last day, **J. L. Emmett**, Rochester, Minn., reported a series of cases in which urinary retention, accompanied by little or no visible evidence of prostatic enlargement, even in the presence of lesions of the spinal cord, such as tabes dorsalis, had been relieved by transurethral resection. This possibility is well known to most urologists, but needs dissemination among other medical men, who, with the best of intentions, deny relief to patients with "cord bladder" or retention of the urine without palpable prostatic enlargement. It is to be remembered that such retentions may occur in young men.

the transfusions (in two cases only one, in the third, three transfusions) the processes were definitely limited and soon healed. The author demonstrated at the same time some results of experimental investigations on rabbits on this subject. These animals were inoculated intracutaneously with staphylococcus and streptococcus organisms and then given a phylactotransfusion (the donor being sensitized only once, three hours before the transfusion). The inflammatory areas on the test animals were then excised at intervals and examined microscopically. It was found that these areas were more completely and rapidly limited on the test animals than on the controls, a difference in reaction which is fully seen from eighteen to thirty hours after the transfusion. These results are in full accord with clinical experience. As this difference in reaction seems to be fully developed during only a short period, the author suggested that the phylactotransfusion be repeated, if necessary, after twenty-four to forty-eight hours.

Gunnar Redell, Uppsala: **Are Anastomotic Operations a Legitimate Procedure in Choledocholithiasis?** In this paper Redell made a comprehensive survey of the literature on the subject as well as a review of the cases treated at Uppsala. This report is to be published in full in the near future and so is abbreviated here. It promises to be the most complete survey ever made of the subject.

Karl Erik Grott, Uppsala: **Sarcomatous Embolism in Left Femoral Artery With Extensive Postembolic Thrombosis. Treatment With Embolectomy and Injection of Heparin Solution in the Artery.**—A married woman, aged 36 years, had an amputation of the right leg in 1937 for sarcoma tibiae. In February, 1939, roentgen examination showed pulmonary metastases. Embolism of the left femoral artery, possibly from a tumor embolus from a pulmonary vein, occurred on February 27, 1939.

Operation was performed ten hours after the onset of symptoms and an embolus and postembolic clot, 8 cm. in length, were removed through an arteriotomy. Extra-arterial massage gave only temporary improvement of the circulation. Through another incision another postembolic clot of not less than 75 cm. came out, but the circulation still showed only a slight improvement. Two more attempts to restore it failed, intra-arterial eupaverin helping temporarily. New clots always appeared after suturing the arteriotomies and the prognosis for the life of the limb seemed very poor. Indeed, the passage in the artery was cleared for the fifth time by arteriotomy and immediately after the incision was sutured 100 mg. heparin (2 c.c. of a 5 per cent solution) was injected in the artery just above the incisions. The circulation in the leg was now definitely restored. Some more heparin and eupaverin were given the following days. Viability of the limb was good and there were no postoperative complications. The patient died a month later from her pulmonary growths.

At necropsy the left common femoral artery showed perfect passage with only a few very small clots attached to the wall. Microscopic examination of the embolus showed sarcomatous involvement of the same type as the primary tumor and the lung metastases.

The impression was gained that in such a case with a very pronounced tendency to form clots at the operative site, the adjuvant treatment with heparin made it possible to get a definite restoration of the circulation after removal of the embolus and the postembolic clots. The intra-arterial injection of heparin at the desired site of action would seem to be more logical than intravenous administration.

professor of surgery at Lund and **Nyström** at Uppsala, while Stockholm has two surgical clinics of university rank, with **Söderlund** and **Hellström** as their heads. The former is at the Serafimer Hospital and the latter at the Maria Hospital. It is of interest that all of these men except Hellström are at or near the retiring age. Petrén just retired this summer, while in May, 1939, Hellström took over the post left open by the retirement of Einar Key. This year and those immediately following thus will see a sweeping change in the leadership of the Swedish university surgical clinics. This is especially true because of the sudden death of the famous Hybbinette, honorary professor in Stockholm, this spring.

This brings up the question of the meaning of the term "honorary professor of surgery" in Sweden. When Hybbinette was alive, there were four such professors: Hybbinette and Giertz in Stockholm and Johannson in Gothenburg (Göteborg) in general surgury and Olivecrona in Stockholm in neurosurgery. These men are appointed honorary professor in recognition of accomplishment, even though they are not university professors or "ordinarius." When it is remembered that some of our American schools may have as many as a half-dozen full professors in one department, the distinction of becoming so in a land where there are only four such positions possible in the whole country is more manifest and the need for a few honorary professorships is also obvious. The honorary professorships at present are held by three men who well deserve them. **Professor Giertz** (*pronounced Yetsch*) is at the Sabbatsberg Hospital in Stockholm and his department is definitely of university caliber, being more scientific than many university clinics in some countries. Similarly the clinic at Gothenburg, which already has scholastic connections because of the presence of a medical academy or nonuniversity medical school, is of a high order. Its leader, **Professor Johannson**, the originator of the threaded flanged nail for collum femoris fractures, is an excellent surgeon and scientist. The neurosurgical clinic of **Professor Olivecrona** needs no comment.

Besides these professorial clinics, there are numerous surgical departments in community hospitals scattered throughout the country. One of the best known of these is that of **Bohmansson** in Örebro, which is a model of organization. Socialized medicine as existing in Sweden today has advantages and disadvantages, a discussion of which is too complex to be made at this time. However, mention will be made, without comment, of the recent doctor's strike at the Serafimer Hospital, Stockholm, where surgeons of university ranking with positions corresponding to associate professors in this country protested because their full-time salaries of $1,250 per annum were to be cut.

The present meeting of the Swedish Surgical Society consisted entirely of papers given by members of the Surgical Clinic in Uppsala and represented a cross-section of the work of that department under the leadership of **Professor Gunnar Nyström**. Visits to many European surgical clinics indicated that this was one of the most progressive and best organized in Europe. **Nyström** is one of the great Swedish surgeons of all time and the character of the younger men in his clinic indicates a continuance of the high standards he has set. The following papers were given:

Henry N. Harkins, Detroit, Mich. (By invitation.): **Physical Factors in Surgical and Traumatic Shock.**—The essential features of this paper have already been reported in the American literature and will not be repeated here.

Harald Lundberg, Uppsala: **Phylactotransfusion.**—Dr. Lundberg demonstrated three cases of septic infection treated with phylactotransfusion. These were all of the phlegmonous type without tendency to limitation, but after

Book Reviews

Cancer of the Colon and Rectum: Its Diagnosis and Treatment. By Fred W. Rankin, M.D., and A. Stephens Graham, M.D. Cloth. Pp. 358, with 133 illustrations. Springfield, Ill., 1939, Charles C. Thomas, Publisher. $5.50.

The experience and study alone which have been compounded to create this book make of it a splendid monograph. In addition, the subject matter is treated in a well-ordered manner and the book is well written.

The senior author has been known as one of the leading exponents of surgery of the large bowel. This judicious monograph justifies fully the credence and authority which his expressions have been lent.

The authors favor the exteriorization operation for excision of the left colon for malignancy when feasible. They trace the development of this operation and the abdominoperineal operation for cancer of the rectum, to which procedure they are partial. For malignancy in the right half of the colon, the authors advocate a one-stage aseptic excision, in which procedure the senior author has had a long experience.

In acute obstruction of the colon the authors favor the performance of cecostomy as the decompressive operative procedure of choice. From his own experience this reviewer cannot agree that an aseptic decompression can be made on the cecum in the presence of great distention as satisfactorily as on the transverse colon. Spontaneous tension perforation of the cecum has apparently not been a frequent occurrence in the experience of the authors. The authors point out quite rightfully that a permanent opening in the transverse colon is not as satisfactory as one in the left inguinal region. The value of an antecedent diversion of the fecal stream by colostomy when the continuity of the gut is to be re-established following a one-stage excision of the left colon is supported by impressive figures.

This text constitutes a worth-while addition to the literature of the management of malignancy of the large bowel and can be recommended enthusiastically.

The Essentials of Modern Surgery. By R. M. Handfield-Jones, University of Cambridge, and A. E. Porritt, Editors. Cloth. Pp. 1,142, with 501 illustrations. Baltimore, 1938, Williams & Wilkins Company. $9.

The editors' expressed object in presenting this text under multiple authorship was to prepare a textbook intermediate between the two or more volume work and the short one volume text aimed at "the less enthusiastic student with sufficient easily assimilable material with which to satisfy the examiners." This unpretentious objective the authors have beyond question achieved.

The concentration of effort of fifteen authors upon this task lends authority to the text; especially is this true when an author writes upon a subject wherein his interest has become well known through original and worth-while contributions to the field.

One criticism of most current surgical texts which can with all fairness be leveled against this one, too, is the lack of specific information concerning the

Gunnar Nyström, Uppsala: **Multiple Nails for Fracture of the Collum Femoris.**—Professor Nyström's method is to use three small flanged nails of his own construction which are inserted in different directions after a careful x-ray-controlled reposition. The advantages of this method are twofold, the fixation of the head is better than when only one large nail is used and the head is less maltreated, the vessels being preserved and late necrosis prevented. The patients stay in bed for three months, although movement is allowed during most of this time, and then they are permitted to walk.

Gunnar Nyström, Uppsala: **Case of Pulmonary Lobectomy for Cancer.**—A woman who had previously been operated upon for carcinoma of the uterus developed a metastatic lesion in the left lung. Because of slowness of the growth and lack of other evident metastases, operation was decided upon. After a previous artificial pneumothorax in several stages, the thorax was opened by extirpation of most of the left seventh rib. The hilus was cut through after ligation; the lumen of the upper main bronchus was coagulated by diathermy, sutured, and covered by a flap of the lower lobe; and a left upper lobectomy was performed. The anesthetic used was evipan. A serothorax developed which organized and at the end of three months the patient felt quite well.

Dr. Lundberg, Uppsala: **A Case of Luxatio Humeri Posterioris Retroglenoidalis.**—The caput humeri could not be kept in position by means of any fixation, but reluxated immediately. For that reason the patient, a man 45 years of age, was operated upon by the method of Hybbinette-Eden. The shoulder joint was opened from behind, the acromioclavicular joint opened, and the acromion chiseled through and drawn laterally. A tibial graft 2 by 5 by 0.3 cm. was put under the periosteum of the back side of the neck of the scapula, extending over the posterior margin of the glenoid cavity about 1 cm. By this means the collum humeri was prevented from sliding back. After fixation of the arm for four weeks, exercise was started and movements became normal after three months.

Gunnar Nyström, Uppsala: **Case Demonstration of Scalenus Syndrome.**—From the last cervical transverse process, which was about 4 cm. long, a fibrous membrane extended down to the first rib. The process and the membrane were removed, with improvement.

Dr. Lundberg, Uppsala: **Narcotal, a New Intravenous Anesthetic.**—Lundberg related the experiences at the Uppsala Clinic with a new Swedish preparation for intravenous anesthesia. In a large series of cases they had good results with no complications. This anesthetic has the following composition:

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for actual diagnosis. The format, printing, and quality of the illustrations are excellent. The book will be useful both for roentgen technicians and for physicians who find it necessary to do roentgenography, but it must be supplemented by other texts.

Roentgen Diagnosis of the Extremities and Spine. By Albert B. Ferguson, M.D. Pp. 465, with 512 illustrations, including 508 x-ray plates, New York, N. Y., 1938, Paul B. Hoeber, Inc. $12.

In this text the author presents the wide experience of the New York Orthopedic Hospital with roentgen diagnosis of lesions of the bones and joints. Even a casual perusal of the text will indicate that the author is well oriented in the pathology of the disorders which he describes; that he is familiar with the clinical manifestations and course of the diseases which he undertakes to discuss, as well as the roentgen signs of the disease, which is his major interest. There are many subtended footnotes throughout the text in which many cross references to cases described and illustrated in the text are made. This should prove a very useful and practical text not alone to roentgenologists, but also to orthopedists and general surgeons. The illustrations are uniformly good. The discussions and descriptions reflect a large, broad experience into which the author has injected a goodly portion of critical study of his own material as well as that of others. Bibliographic references to original sources would have enhanced the value of the book.

The Art of Anesthesia. By Paluel J. Flagg, M.D. Ed. 6, revised. Cloth. Pp. 491, with 161 illustrations. Philadelphia, 1939, J. B. Lippincott Company.

To revise adequately a book on any phase of medical science is a stupendous undertaking. The rapid progress made in anesthesiology during the past twenty years makes the satisfactory bringing up to date of a book written two decades ago exceptionally difficult. The original title, *The Art of Anesthesia*, has been retained for this sixth edition of Dr. Flagg's book. In spite of the title, some science has crept in, whether with or without the author's intention it is difficult to determine.

In the preface to the sixth edition the author raises the question of terminology, suggesting the word "pneumatology" in place of the current "anesthesiology." It will be remembered that John Snow, the first great anesthetist, in 1847 objected to "anesthesia" and voted for "narcosis." However, common usage is probably the determining factor in such matters, and "anesthetic," "anesthesia," and "anesthesiology" doubtless will survive. In this reviewer's opinion, the author is correct in his contention that the anesthetist's necessary daily experience with the depression accompanying pain relief makes him the logical member of the hospital staff to be concerned with the therapy of acute respiratory and possibly circulatory disorders.

The following is a quotation from the preface: "The Pneumatic Institute of Sir Thomas Beddoes provided a nucleus about which the pneumatologists of the period brought to a focus the earlier work of Hickman, Priestly, and others." Beddoes' Pneumatic Institute was discontinued as such in 1800 and Henry Hill Hickman was born in that year. Joseph Priestley spelled his name Priestley. The quotation is illustrative of many inaccuracies throughout the book, some of which are not so innocuous as these.

risks, as well as the results, of operation. The student has a right to expect information of this sort in a text. Another serious defect is the omission of textual references to original sources. It would almost seem that a studied effort had been made to eliminate completely this stimulating influence upon students of mentioning the names of those whose contributions extend knowledge within the field under consideration.

It may be questioned whether a textbook on general surgery may include justifiably chapters on diseases of the skin, the ear, and affections of the nose and accessory sinuses, when indications for, and the risks and results of, operations are treated in a superficial manner.

Rontgendiagnostik des Chirurgen. By Prof. Dr. Otto Kingreen. Paper. Pp. 325, with 527 illustrations. Leipzig, 1939, Johann Ambrosius Barth. RM 32 bound, and RM 30 unbound.

This volume follows the usual form of German language texts. It is concerned chiefly with the application of the roentgen method in the diagnosis of surgical conditions, but there is a rather general discussion of the whole field of x-ray diagnosis. An introductory chapter concerning methods of x-ray examination, equipment, and technique of x-ray diagnosis is very informative. The detailed discussions of foreign body localization and of fractures will be of considerable value to surgeons. There is, however, surprisingly little attention devoted to the roentgen findings in the acute abdominal lesions, such as intestinal obstruction, or to a description of the appearance of the thorax and the gastrointestinal tract following surgical procedures. The illustrations of roentgenograms are numerous, well chosen, and well reproduced, but there are surprisingly few diagrams. A bibliography is not included. While a book of this kind will be useful to surgeons and radiologists, it adds little to the textbooks of roentgen diagnosis already available.

Roentgen Technique. By Clyde McNeill, M.D. Cloth. Pp. 315, with 274 illustrations. Springfield, Ill., 1939, Charles C. Thomas, Publisher. $5.

The importance of roentgenograms of a high technical quality cannot be overemphasized, hence any contribution to this subject is important. Although it does not pretend to be a complete study of roentgenologic technique, this volume contains valuable material in this field. Essentially it is devoted to a pictorial demonstration of positioning for various roentgen examinations. Theoretical considerations, the physics of roentgen technique, details as to equipment and darkroom procedure are largely omitted. With very few exceptions, all the usual x-ray technical procedures are described with the various positions which are desirable for each type of examination. Each anatomical position is beautifully delineated both by diagrams and actual photographs. The technique of certain newer procedures, such as kymography, tomography, pelvic measurements, and others, are thoroughly elucidated. While there are some references to roentgen diagnostic findings, these are purely incidental. The details of roentgen anatomy which are given are substantially correct, although many important details are omitted or presented in gross form. The data on ossification centers, for example, while accurate enough for orientation purposes, are not to be relied on

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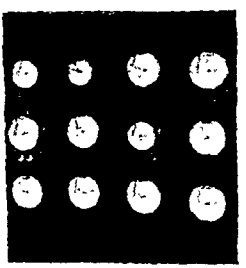


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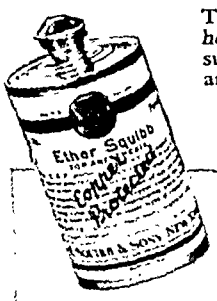
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Evidence of careless editorial effort or of unfamiliarity with the abundant literature of the last few years is shown in many chapters on widely divergent subjects. For example, in Chapter III entitled "The Signs of Anesthesia," a heterogeneous handling of the physical changes accompanying increasing dosage of inhalation agents could have been as well written twenty years ago. It ignores some of the contributions made to the subject by Arthur Guedel, by the author's old preceptor, Albert Miller, and by others. The subjects of artificial respiration and fluid therapy are curiously touched upon in this same chapter and in a manner to confuse the reader and make difficult a comprehension of the author's ideas regarding physical signs. Again, in describing the use of nonvolatile agents for basal narcosis and for block anesthesia, the reviewer wonders whether lack of clear-cut statements regarding drugs, pharmacologic action, technique of administration, indications and contraindications is due to inexperience, lack of familiarity with current literature, or simply due to incomplete revision of the older text. Certainly the contents of these and other chapters cannot be taken as a safe guide to clinical practice.

As a record of the beliefs and practice of one individual anesthetist, this book is interesting reading and contains valuable information. As a text, it can scarcely be considered authoritative or representative of the current teaching and practice of anesthesiology in 1939.

Brazilian Medical Contributions. By L. Ribeiro. Paper. Pp. 181, with 62 illustrations. Rio de Janeiro, 1939, Livraria Jose Olympio.

The preparation of this volume recounting the most important aspects of the development of medicine in Brazil was occasioned by the Brazilian exhibit at the New York World's Fair. The avowed purpose of the book is to make available to the libraries and universities of the United States a small volume that will tell of some of the contributions that Brazil has made to medical science. At the same time it sketches the attempts that are being made to meet the health problems of that country. The book contains an assortment of unrelated chapters describing the various scientific institutes; the official public health structure of the country; the campaign against tuberculosis, leprosy, and yellow fever; the mineral spas of Brazil; the work of outstanding figures in Brazilian medical development; and summaries of three or four interesting programs of study. The book is of value to the reader who is interested in learning of some of the medical and health problems of a nation of which the average citizen of the United States has but the vaguest ideas. It is unfortunate that a book of this character should not have been submitted to the editorial and typographical scrutiny of one more conversant with idiomatic English, thus avoiding the peculiarities and stiltedness of style as well as errors that make the book hard to read. It is generously illustrated with pictures and diagrams.

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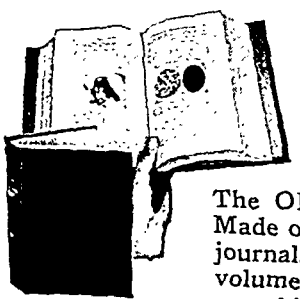
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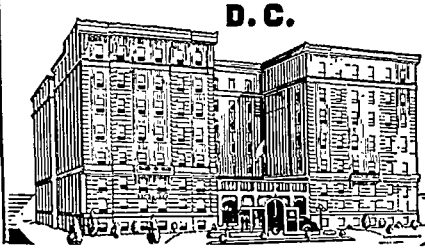
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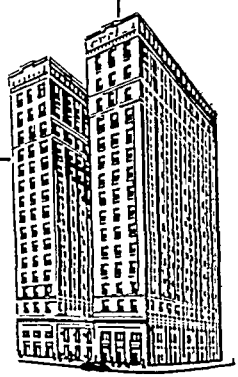
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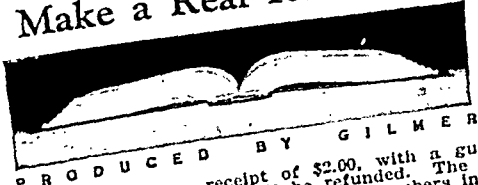
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